A SKETCH

OF THE

GEOGRAPHY AND GEOLOGY

OF THE

HIMALAYA MOUNTAINS AND TIBET

BY

COLONEL S. G. BURRARD, R.E., F.R.S.,

SUPERINTENDENT, TRIGONOMETRICAL SURVEYS,

AND

H. H. HAYDEN, B.A., F.G.S., (later Sir Henry Hayden, Kt., C.S.I., C.I.E., F.R.S.)

SUPERINTENDENT, GEOLOGICAL SURVEY OF INDIA.

REVISED BY

COLONEL SIR SIDNEY BURRARD, K.C.S.I., F.R.S.,

AND

A. M. HERON, D. Sc., F.G.S., F.R.G.S., F.R.S.E.,

SUPERINTENDENT, GEOLOGICAL SURVEY OF INDIA.

DELHI: MANAGER OF PUBLICATIONS

1933

Price Rs. 28 or £2 3s. 6d.

Sold at the Office of the Geodetic Branch, Survey of India, Dehra Dun.

PREFACE TO FIRST (1908) EDITION

IN 1807 a Survey detachment was deputed by the Surveyor General of Bengal to explore the source of the Ganges: this was the first expedition to the Himālaya undertaken for purely geographical purposes. A hundred years have now elapsed, during which geographical and geological information has been steadily accumulating and we have at length reached a stage where there is danger of losing our way in a maze of unclassified detail: it is therefore desirable to review our present position, to co-ordinate our varied observations and to see how far we have progressed and what directions appear favourable for future lines of advance.

The present paper originated in a proposal submitted by the Survey of India to the Board of Scientific Advice at the meeting of the latter in May 1906. The proposal was as follows: "The number of travellers in the Himālaya and Tibet "is increasing, and a wider interest is being evinced by the public in the geography "of these regions. It is therefore proposed to compile a paper summarizing the "geographical position at the present time."

Subject to the modification that the scope of the paper should be geological as well as geographical, this proposal has received the sanction of the Government of India and the work has been entrusted to us to carry out. On the understanding that the paper is intended primarily for the use of the public, we have endeavoured to avoid purely technical details and to present our results in a popular manner.

Our subject has fallen naturally into four parts, as follows:

PART I. The high peaks of Asia.
PART II. The principal mountain ranges of Asia.
PART III. The rivers of the Himālaya and Tibet.
PART IV. The geology of the Himālaya.

Though the four parts are essentially interdependent, each has been made as far as possible complete in itself and will be published separately. The first three parts are mainly geographical, the fourth part is wholly geological: the parts are subdivided into sections, and against each section in the table of contents is given the name of the author responsible for it.

The endeavour to render each part complete must be our apology for having repeated ourselves in more places than one: the relations, for instance, of a range to a river have been discussed in Part II, when the range was being described and have been mentioned again in Part III under the account of the river.

As the mountains of Asia become more accurately surveyed, errors will doubtless be found in what we have written and drawn: it is not possible yet to arrive at correct generalizations and we have to be content with first approximations to truth.

Maps, too large for insertion in such a volume as this, are required for a study of the Himālayan mountains: the titles of maps illustrating the text are given in footnotes and are procurable from the Map Issue Office of the Survey of India in Calcutta. Constable's hand-atlas of India will be found useful.

We are much indebted to Babus Shiv Nath Saha and Ishan Chandra Dev, B.A., for the care with which they have checked our figures and names, and to Mr. J. H. Nichol for the trouble he has taken to ensure the correctness of the charts. Mr. Eccles and Major Lenox Conyngham have been kind enough to examine all proofs, and to give us the benefit of their advice and suggestions. Mr. Eccles has also supervised the drawing and printing of the charts, and we have profited greatly by the interest he has shown in them.

We have also to express our indebtedness to Messrs. T. D. La Touche and C. S. Middlemiss for their kind assistance in examining proofs of Part IV.

S. G. BURRARD.
H. H. HAYDEN.

December 1908.

PREFACE TO THE SECOND (1932) EDITION

THIS book on the Himālaya Mountains and Tibet was originally compiled as a centenary review of the geographical and geological knowledge which had been gained during 1807–1907. The book has proved invaluable as a work of reference for surveyors and explorers, and there has been a steady public demand for it both in India and Europe.

As the original edition printed in 1907 has become exhausted it has been deemed very desirable to issue a second edition and to have this brought up to date. Of the two authors who jointly prepared the original book, Sir Henry Hayden was killed on the Alps by a fall of rock in 1923, and Sir Sidney Burrard retired from the service in 1919. Sir Sidney Burrard was asked if he would be willing to undertake the revision of the geographical portions, and this he has most kindly undertaken in collaboration with the Geodetic Branch office. The great advantage of having this important work re-written as regards its geographical portions by an original author of the unique standing of Sir Sidney Burrard is very cordially recognized.

The task of revising Sir Henry Hayden's geological contributions and of bringing them up to date has been entrusted to Dr. A. M. Heron, who requests that acknowledgment may be made of the help given by Dr. G. de P. Cotter in questions of geological correlation and by Messrs. D. N. Wadia, W. D. West and J. B. Auden in the compilation of the geological maps of the Himālaya that accompany this work.

R. H. Thomas, *Brigadier*,
Surveyor General of India.

L. L. Fermor,
Offg. Director, Geological Survey of India.

March 1932.

CONTENTS

PART I

PART II

PART III

PART III—(*Contd.*)

PART IV

CHARTS AND PLATES

PART I

PART II

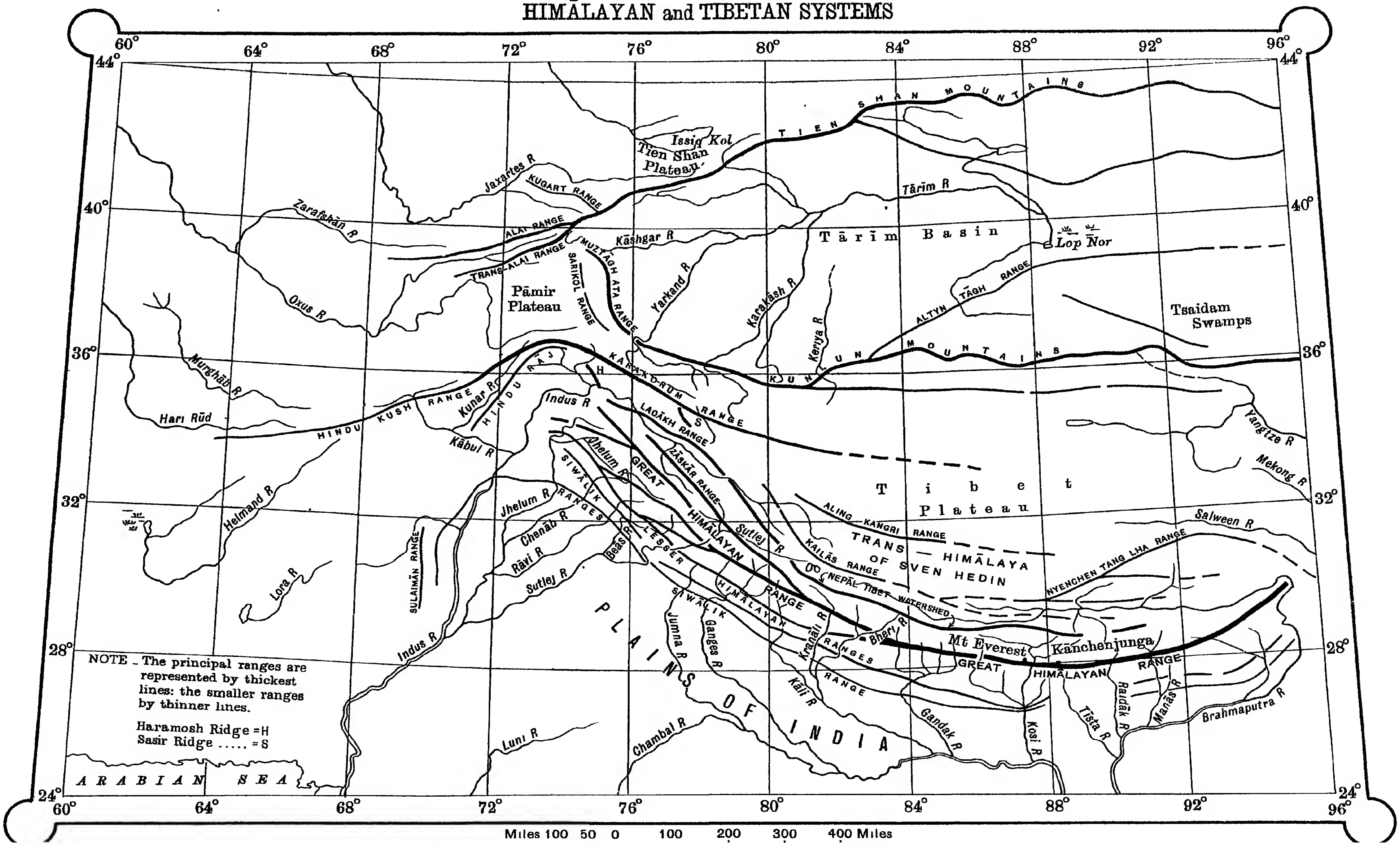
PART II—(*Contd.*)

PART III

PART IV

PART IV—(*Contd.*)

CHART
to illustrate the TRENDS of the principal Mountain ranges of the HIMĀLAYAN and TIBETAN SYSTEMS



THE HIGH PEAKS OF ASIA.

CHAPTER 1.

THE PRINCIPAL PEAKS AND THEIR ALTITUDES.

IN the earlier stages of geographical investigation the most important features of a mountain mass are the high peaks. They may be, it is true, but slight prominences of lofty ranges and they may possess perhaps no geological significance: but they are conspicuous and definite points; they are the only mountain features that can be observed with accuracy from a distance; and the determination of their positions and heights is the first step of the ladder of geographical knowledge. When this step has been taken, further progress becomes possible; the peaks can be made the basis of subsequent surveys; the courses of rivers and the positions of lakes can be laid down with regard to them; the trends and forms and magnitudes of the ranges can be inferred from the distribution of the peaks.

In the following Tables I to V all the peaks of Asia that have been found to exceed 24,000 feet in height are catalogued in order of magnitude: their geographical positions are shown in the five corresponding charts, numbered also I to V.

TABLE I.—Peaks of the first magnitude, exceeding 28,000 feet in height.

Reference Number of Peak. 1	Name or Symbol. 2	Peak and Sheet Numbers. 3	Number of stations from which the height was observed. 4	System. 5	Height. 6	Latitude. 7	Longitude. 8
					feet	° ′ ″	° ′ ″
1	Mount Everest . .	37/72 I	6	Nepāl Himālaya .	29,002	27 59 16	86 55 40
2	K²	13/52 A	9	Karakorum . .	28,250	35 52 55	76 30 51
3	Kānchenjunga . .	10¹/78 A	9	Nepāl Himālaya .	28,146	27 42 09	88 09 00

TABLE II.—Peaks of the second magnitude, between 27,000 and 28,000 feet in height.

Reference Number of Peak. 1	Name or Symbol. 2	Peak and Sheet Numbers. 3	Number of stations from which the height was observed. 4	System. 5	Height. 6	Latitude. 7	Longitude. 8
					feet	° ′ ″	° ′ ″
4	E¹	Sheet 72 I	..	Nepāl Himālaya .	27,890	27 57 43	86 56 10
5	Kānchenjunga II . .	10²/78 A	7	Nepāl Himālaya .	27,803	27 41 30	88 09 24
6	Makālu . . .	2/72 M	6	Nepāl Himālaya .	27,790	27 53 23	87 05 29

TABLE III.—Peaks of the third magnitude, between 26,000 and 27,000 feet in height.

Reference Number of Peak. 1	Name or Symbol. 2	Peak and Sheet Numbers. 3	Number of stations from which the height was observed. 4	System. 5	Height. 6	Latitude. 7	Longitude. 8
					feet	° ′ ″	° ′ ″
7	Dhaulāgiri	9/62 P	7	Nepāl Himālaya	26,795	28 41 48	83 29 42
8	Cho Oyu	5/71 L	5	Nepāl Himālaya	26,750	28 05 32	86 39 51
9	Kutang I	14/71 D	3	Nepāl Himālaya	26,658	28 33 00	84 33 43
10	Nanga Parbat I	48/43 I	8	Punjab Himālaya	26,620	35 14 21	74 35 24
11	Annapurna I	Sheet 62 P	8	Nepāl Himālaya	26,492	28 35 44	83 49 19
12	Gasherbrum I	23/52 A	4	Karakorum	26,470	35 43 30	76 41 48
13	Broad Peak	16/52 A	..	Karakorum	26,400	35 48 35	76 34 23
14	Gasherbrum II	21/52 A	2	Karakorum	26,360	35 45 31	76 39 15
15	Gosainthān	46/71 H	2	Nepāl Himālaya	26,291	28 21 07	85 46 55
16	Gasherbrum IV	19/52 A	2	Karakorum	26,180	35 45 38	76 37 02
17	Gasherbrum III	20/52 A	2	Karakorum	26,090	35 45 36	76 38 33
18	Annapurna II	3/71 D	5	Nepāl Himālaya	26,041	28 32 05	84 07 26

TABLE IV.—Peaks of the fourth magnitude, between 25,000 and 26,000 feet in height.

Reference Number of Peak. 1	Name or Symbol. 2	Peak and Sheet Numbers. 3	Number of stations from which the height was observed. 4	System. 5	Height. 6	Latitude. 7	Longitude. 8
					feet	° ′ ″	° ′ ″
19	Gyachung Kang	3/71 L	1	Nepāl Himālaya	25,990	28 05 52	86 44 41
20	Dasto Ghil	20/42 P	2	Karakorum	25,868	36 19 35	75 11 20
21	Himalchuli	19/71 D	4	Nepāl Himālaya	25,801	28 26 03	84 38 34
22	Kangbachen	9/78 A	4	Nepāl Himālaya	25,782	27 42 59	88 06 47
23	Ngojumba Kang	2/71 L	4	Nepāl Himālaya	25,730	28 06 24	86 41 15
24	Kutang II	16/71 D	2	Nepāl Himālaya	25,705	28 30 12	84 34 07
25	E^2	Sheet 72 I	..	Nepāl Himālaya	25,700	27 57 53	86 53 23
26	Masherbrum East	7/52 A	7	Karakorum	25,660	35 38 36	76 18 31
27	Nanda Devi	115/53 N	9	Kumaun Himālaya	25,645	30 22 32	79 58 22
28	Chomo Lonzo	1/72 M	2	Nepāl Himālaya	25,640	27 55 47	87 06 44
29	Masherbrum West	8/52 A	3	Karakorum	25,610	35 38 29	76 18 23
30	Nanga Parbat II	47/43 I	2	Punjab Himālaya	25,572	35 15 22	74 35 14
31	Rakaposhi	27/42 L	3	Haramosh Ridge	25,550	36 08 39	74 29 22
32	Hunza-Kunji I	32/42 L	3	Karakorum	25,540	36 30 39	74 31 26
33	Kunjut No. 1	12/42 P	2	Karakorum	25,460	36 12 21	75 25 03
34	Kāmet	49/53 N	6	Zāskār Range	25,447	30 55 13	79 35 37
35	Namcha Barwa	5/82 O	..	Assam Himālaya	25,445	29 37 51	95 03 31
36	XLIII	5/62 P	5	Nepāl Himālaya	25,429	28 45 45	83 23 25
37	Sherpigang I	36/52 A	4	Karakorum	25,400	35 24 01	76 50 55
38	Gurla Mandhāta	7/62 F	2	Nepāl Tibet Water-shed.	25,355	30 26 18	81 17 57
39	Jano	13/78 A	9	Nepāl Himālaya	25,294	27 40 56	88 02 47
40	Hunza-Kunji II	31/42 L	1	Karakorum	25,294	36 31 54	74 30 01
41	Sherpigang II	35/52 A	4	Karakorum	25,280	35 24 24	76 50 50
42	K^{22}	29/52 F	2	Sasir Ridge	25,280	34 52 00	77 45 13
43	XLIV	6/62 P	3	Nepāl Himālaya	25,271	28 45 13	83 22 46
44	Tirich Mīr I	7/37 P	2	Hindu Kush	25,263	36 15 21	71 50 32
45	B^{504}	44/71 H	2	Nepāl Himālaya	25,134	28 21 17	85 48 45
46	Makālu II	Sheet 72 M	..	Nepāl Himālaya	25,120	27 54 58	87 04 54
47	Chogolisa	25/52 A	4	Karakorum	25,110	35 36 44	76 34 23
48	Satellite of Gosainthān	7/62 P	7	Nepāl Himālaya	25,064	28 44 07	83 18 53
49	Kungur *	4/42 N	2	Muztāgh Ata	25,146	38 39 23	75 13 05

* Sir Aurel Stein prefers the spelling Kongur.

TABLE V.—Peaks of the fifth magnitude, between 24,000 and 25,000 feet in height.

Reference Number of Peak.	Name or Symbol.	Peak and Sheet Numbers.	Number of stations from which the height was observed.	System.	Height.	Latitude.	Longitude.
1	2	3	4	5	6	7	8
					feet	° ′ ″	° ′ ″
50	Boiohaghūrduānasir	33/42 L	8	Karakorum	24,970	36 26 30	74 40 52
51	XLV	8/62 P	5	Nepāl Himālaya	24,885	28 44 03	83 21 51
52	Kula Kangri I	19/77 L	2	Assam Himālaya	24,784	28 14 02	90 37 09
53	XXXVI	18/62 P	4	Nepāl Himālaya	24,750	28 35 03	83 59 31
54	Kula Kangri II	13/77 L	4	Assam Himālaya	24,740	28 02 49	90 27 30
55	E^3	Sheet 71 L	..	Nepāl Himālaya	24,730	28 01 27	86 54 47
56	Kula Kangri III	12/77 L	1	Assam Himālaya	24,710	28 03 13	90 27 28
57	Mamostong	12/52 E	1	Karakorum	24,690	35 08 54	77 34 41
58	XXXV	2/71 D	4	Nepāl Himālaya	24,688	28 32 11	84 05 05
59	Kula Kangri IV	11/77 L	1	Assam Himālaya	24,660	28 04 11	90 26 53
60	K^{24}	31/52 F	2	Sasir Ridge	24,650	34 48 14	77 48 22
61	K^{23}	30/52 F	2	Sasir Ridge	24,590	34 50 31	77 47 16
62	Noshaq	Sheet 37 P	..	Hindu Kush	24,573	36 26 06	71 05 08
63	Tirich Mīr II	Sheet 37 P	2	Hindu Kush	24,564	36 15 47	71 49 52
64	Teram Kangri	15/52 E	4	Karakorum	24,489	35 34 38	77 05 04
65	Jonsong	90/78 A	2	Nepāl Himālaya	24,472	27 52 52	88 08 12
66	Indus-Nagar Watershed No. 2.	46/42 L	2	Haramosh Ridge	24,470	36 00 14	74 52 34
67	Tirich Mīr III	Sheet 37 P	2	Hindu Kush	24,461	36 16 00	71 49 31
68	LVII	116/53 N	3	Kumaun Himālaya	24,391	30 21 58	79 59 54
69	Muztāgh Ata	7/42 N	2	Muztāgh Ata	24,388	38 16 43 / 38	75 07 06 / 02
70	K^{12}	8/52 E	4	Karakorum	24,370	35 17 46	77 01 23
71	Close companion of K^{23} and K^{24}	48/52 F	..	Sasir Ridge	24,330	34 52 25	77 44 18
72	Kunlun No. 1	3/61 E	2	Kunlun	24,306	35 47 48	81 08 42
73	Ganesh Himal	6/71 H	1	Nepāl Himālaya	24,299	28 23 30	85 07 45 / 46
74	Kondus	50^2/52 A	..	Karakorum	24,280	35 31 06	76 48 07
75	Istor-o-Nal / Tirich Mīr IV	Sheet 37 P	2	Hindu Kush	24,271	36 22 38	71 53 52
76	Haramosh	58/43 I	3	Haramosh Ridge	24,270	35 50 29	74 53 52
77	Rimo Peak	51/52 E	2	Karakorum	24,230	35 21 22	77 22 09
78	West Ibi Gamin	48/53 N	..	Zāskār Range	24,200	30 57 03	79 34 10
79	East Ibi Gamin	Sheet 53 N	..	Zāskār Range	24,170	30 55 57	79 36 09
80	Churen Himal	4/62 P	7	Nepāl Himālaya	24,150	28 43 54	83 12 43
81	Sad Ishtrāgh	1/42 D	2	Hindu Kush	24,110	36 32 57	72 06 58
82	Kunjut No. 3	7/42 P	2	Karakorum	24,090	36 19 03	75 02 11 / 10
83	Satellite of Kānchenjunga	6/78 A	2	Nepāl Himālaya	24,089	27 47 15	88 11 55
84	Nalkankar	Sheet 62 F	..	Nepāl-Tibet Watershed.	24,064	30 17 14	81 23 30
85	Chamlang	42/72 I	2	Nepāl Himālaya	24,012	27 46 31	86 58 56
86	Kabru	16/78 A	2	Nepāl Himalaya	24,002	27 36 30	88 06 50

TABLE VI.—Other peaks of more than 24,000 feet, whose positions and heights are not yet sufficiently well known for inclusion in Tables I—V.

Reference Number of Peak.	Name or Symbol.	Peak and Sheet Numbers.	Number of stations from which the height was observed.	System.	Height.	Latitude.	Longitude.
1	2	3	4	5	6	7	8
					feet	° ′ ″	° ′ ″
87	N. E. Satellite of K^2 .	57/52 A	..	Karakorum . .	24,750	35 55 25	76 33 28
88	N. H. I	Sheet 62 P	2	Nepāl Himālaya .	24,509	28 36 50	83 52 25
89	Garmo	Sheet 42 B	..	Trans-Alai Range	24,590	38 56 40	72 01 20
90	Kunjut No. 2 . .	11/42 P	1	Karakorum . .	24,580	36 12 45	75 15 12
91	Satellite of Kānchenjunga	2/78 A	5	Nepāl Himālaya .	24,344	27 52 40	88 08 35
92	Tirich Mīr V . . .	Sheet 37 P	2	Hindu Kush .	24,076	36 16 17	71 48 52
93	Hunza-Kunji IV . .	34/42 L	5	Karakorum . .	24,044	36 24 10	74 41 43

The question, "what constitutes a peak," has been considered in Chapter 18, Part III, in a reference to the discovery of Teram Kangri. The question, "By whom was Mount Everest discovered?," is considered in Chapter 21, Part III, in a reference to the Nepāl Himālaya.

A column has been included in Tables I to V showing the number of stations from which the height of each peak has been observed. For the attainment of accuracy it is more profitable to observe a peak from different places and distances than to multiply observations from any one station; and the number of observing stations is an indication of the trustworthiness of the resulting value of altitude. The accuracy of the adopted values of height is discussed hereafter and numerical estimates of the magnitudes of the errors that may exist are formed.

A column has also been included showing the Survey of India number and sheet of each peak, in case the reader requires more detailed information.

The latitude and longitude of each peak have been given in the tables, so that its position on the charts may be ascertained. In the drainage Charts XXIV to XXXIV (appended to Part III) these positions have been marked exactly: but in Charts I to V the scale is so small that in crowded clusters there has not been always room to mark the precise position of each peak; a few of the symbols overlapped, and had to be slightly displaced in order to make room for others.

It will be noticed that every peak of Chart I is shown by a larger and larger circle on each of the successive Charts II to V; the reason for this increase is that at the level of 28,000 feet Kānchenjunga, for example, is in nature hardly more than a point, but at 27,000 feet the contour round Kānchenjunga encloses an *area*; and at 24,000 feet a horizontal section taken through the Kānchenjunga

pyramid would show that a *considerable* area of the earth's surface had attained that elevation.*

In the fifth column of each table is given the range on which each peak is situated, the great Himālaya range being divided into four sections :—

(i) the Punjab Himālaya from the Indus to the Sutlej ;
(ii) the Kumaun Himālaya from the Sutlej to the Kāli ;
(iii) the Nepāl Himālaya from the Kāli to the Tīsta ;
(iv) the Assam Himālaya from the Tīsta to the Brahmaputra.†

The relative positions of the ranges mentioned in the tables are shown on the range chart which serves as a frontispiece.

Well-known peaks below 24,000 feet.—In Table VII are given the details of a few well-known peaks, which are *less* than 24,000 feet in height. This table unlike the preceding does not contain the names of all peaks above a certain height, and is not therefore a continuation of Table V. Some peaks have been omitted which exceed in height many of those of Table VII ; to give complete lists of all known peaks would be to convert this paper into a numerical catalogue.

A great many of the peaks of Table VII are visible from Mussoorie and Landour, and their outlines are shown in Chart VIII.‡ The panorama of Chart VIII is continuous from left to right : it has been drawn in three sections that it might be made to fit the size of this paper. The reference letters A and B have been added to indicate continuity.

TABLE VII.—Some well-known peaks, the heights of which are less than 24,000 feet.

Reference Number of Peak. 1	Name or Symbol. 2	Peak and Sheet Numbers. 3	Number of stations from which the height was observed. 4	System. 5	Height. 6	Latitude. 7	Longitude. 8
					feet	° ′ ″	° ′ ″
94	Api	160/62 B	3	Nepāl Himālaya	23,399	30 00 20	80 55 54
95	Badrīnāth	27/53 N	5	Kumaun Himālaya	23,190	30 44 16	79 16 52
96	Bandarpūnch	69/53 I	5	Kumaun Himālaya	20,720	31 00 12	78 33 17
97	Chomo Lhāri	38/78 E	2	Assam Himālaya	23,997	27 49 42	89 16 21
98	Chumunko	80/78 A	4	Nepāl Himālaya	17,310	27 27 31	88 47 12
99	Dayabhang	35/71 H	2	Nepāl Himālaya	23,750	28 15 22	85 31 09
100	Deotibba	20/52 H	5	Punjab Himālaya	20,410	32 12 51	77 23 54
101	Dubanni	38/43 I	1	Haramosh Ridge	20,154	35 57 23	74 38 05
102	Dūnagiri	108/53 N	4	Kumaun Himālaya	23,184	30 30 57	79 52 04

* On Chart V peaks of the fifth magnitude have been drawn as points, those of the fourth magnitude have been given a diameter of 6 miles, those of the third a diameter of 12 miles, those of the second a diameter of 18 miles, and those of the first a diameter of 24 miles.

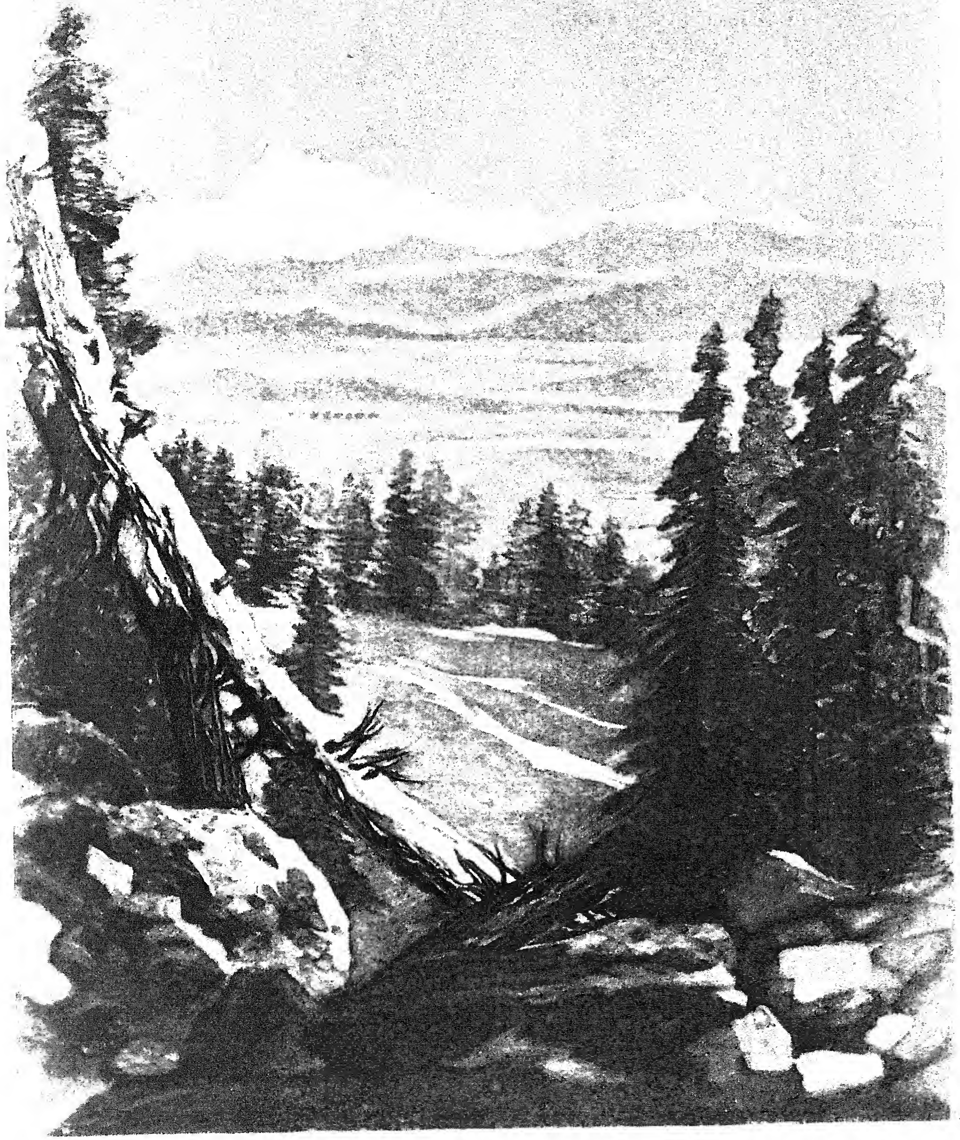
† The Punjab and Kumaun Himālaya have been for the most part surveyed ; the peaks of the Nepāl Himālaya have been observed from long distances and the country was topographically surveyed in 1924 : the Assam Himālaya form still a *terra incognita*, although many of the peaks have been well observed from the south, and surveys of an exploratory nature have been carried out in 1911-13 and 1921-22.

‡This chart was copied from the panorama drawn by Col. St. G. C. Gore, C.S.I., R.E., in 1887.

TABLE VII.—Some well-known peaks, the heights of which are less than 24,000 feet—*contd.*

Reference Number of Peak. 1	Name or Symbol. 2	Peak and Sheet Numbers. 3	Number of stations from which the height was observed. 4	System. 5	Height 6	Latitude. 7	Longitude. 8
					feet	° ′ ″	° ′ ″
103	Gangotri*	11/53 J	3	Kumaun Himālaya	21,700	30 52 58	78 52 14
104	Gardhār	13/52 D	1	Punjab Himālaya	21,140	32 55 07	76 42 48
105	Gauri Sankar†	6/72 I	6	Nepāl Himālaya	23,440	27 57 52	86 20 16
106	Gyala Peri	Sheet 82 K	..	Assam Himālaya	23,460	29 48 52	94 59 05
107	Jaonli	17/53 J	1	Kumaun Himālaya	21,760	30 51 17	78 51 25
108	Jibjibia East ‡	57/71 H	2	Nepāl Himālaya	21,839	28 07 41	85 52 16
109	Jibjibia West	55/71 H	2	Nepāl Himālaya	22,876	28 10 25	85 46 51
110	Kailās	Sheet 62 E	2	Kailās	22,028	31 04 02	81 18 50
111	Kaufmann	Sheet 42 A	..	Trans-Alai	23,000	39 18 20	72 50 03
112	Kedārnāth	7/53 N	6	Kumaun Himālaya	22,770	30 47 53	79 04 07
113	Kharchakund	8/53 N	1	Kumaun Himālaya	21,695	30 46 46	79 07 47
114	Kungpu	36/78 E	..	Assam Himālaya	22,252	27 50 46	89 20 16
115	Lunkho	Sheet 42 D	2	Hindu Kush	22,641	36 46 36	72 26 16
116	Mer or Kāna§	7/52 B	2	Punjab Himālaya	23,250	34 00 48	76 03 22
117	Muztāgh	1/61 A	..	Kunlun	23,890	35 56 21	80 14 10
118	Nampa	Sheet 62 F	4	Nepāl Himālaya	22,162	30 00 37	81 00 03
119	Nandakna	76/53 N	2	Kumaun Himālaya	20,700	30 20 56	79 43 09
120	Nandakot	41/62 B	3	Kumaun Himālaya	22,510	30 16 51	80 04 11
121	Narsing	44/78 A	4	Nepāl Himālaya	19,130	27 30 40	88 17 02
122	Nilakanta	28/53 N	3	Kumaun Himālaya	21,640	30 43 52	79 24 28
123	Nodzinkangsa	1/77 L	..	Nepāl-Tibet Water-shed.	23,794	28 57 16	90 11 33
124	Nyenchen-tang-lha.	5/77 J	3	Nyenchen-tang-lha.	23,255	30 22 17	90 35 18
125	Pānch Chūlhi	92/62 B	3	Kumaun Himālaya	22,650	30 12 51	80 25 41
126	Pandim	18/78 A	8	Nepāl Himālaya	22,010	27 34 38	88 13 10
127	Pauhunri	69/78 A	2	Nepāl Himālaya	23,180	27 56 56	88 50 39
128	Riwo Phargyul North ‡	39/53 I	2	Zāskār	22,210	31 54 08	78 44 39
129	Riwo Phargyul South	41/53 I	2	Zāskār	22,170	31 53 05	78 44 05
130	Sargaroin	64/53 I	2	Kumaun Himālaya	20,370	31 06 08	78 30 04
131	Ser or Nāna‖	1/52 C	6	Punjab Himālaya	23,410	33 58 56	76 01 31
132	Simvo	14/78 A	2	Nepāl Himālaya	22,360	27 40 44	88 14 38
133	Srikānta	7/53 J	4	Kumaun Himālaya	20,120	30 57 25	78 48 22
134	Tengri Khān	Sheet 11, Chinese Turkistān and Kansu.	..	Tien Shan	23,600	42 24 10	80 16 43
135	Tharlasagar	14/53 J	2	Kumaun Himālaya	22,610	30 51 41	78 59 45
136	Trisūl East	121/53 N	4	Kumaun Himālaya	22,320	30 16 14	79 52 24
137	Trisūl West	117/53 N	7	Kumaun Himālaya	23,360	30 18 43	79 46 40

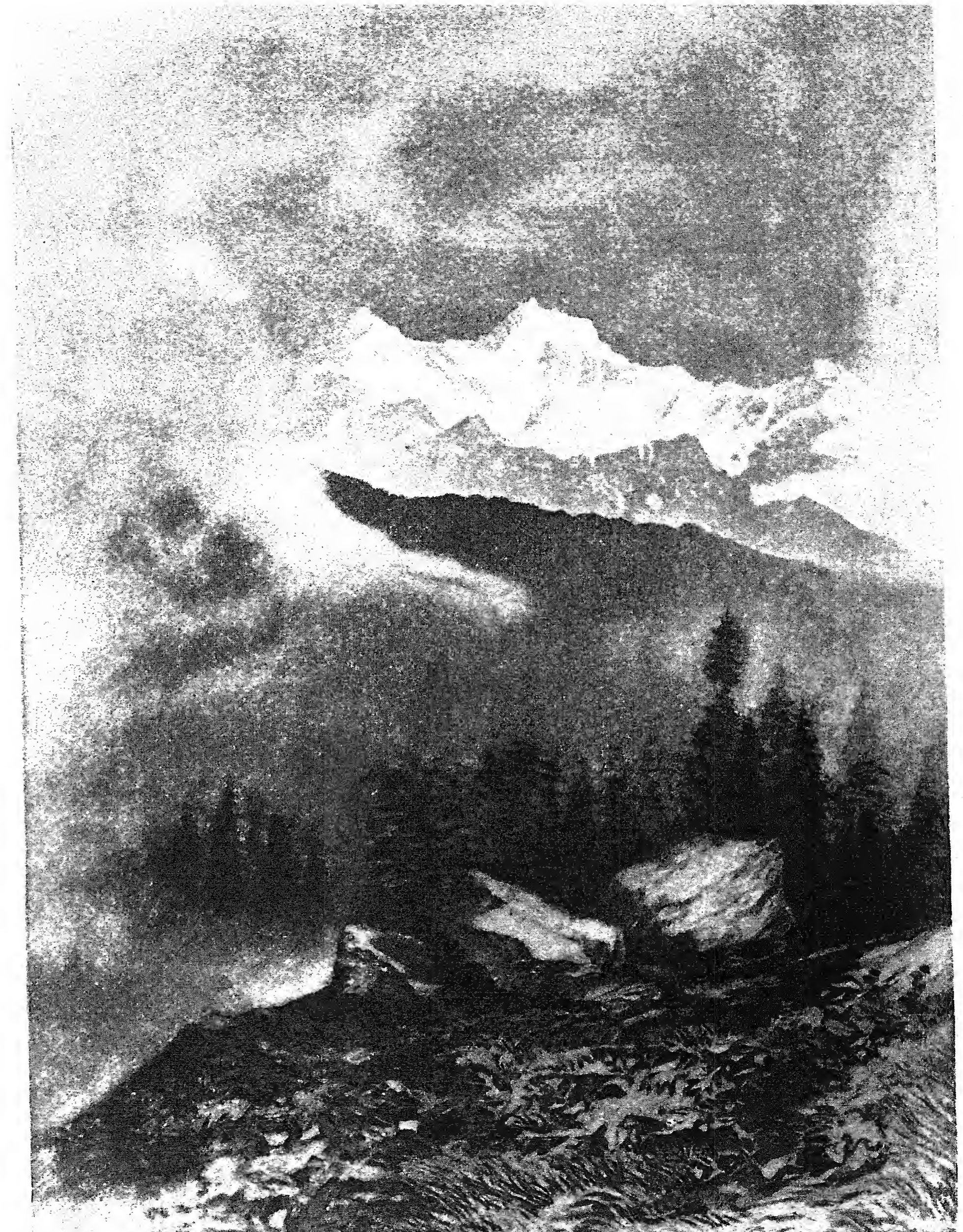
*The twin of Jaonli.
†Double-peaked.
‖The twin of Mer.
‡Twins.
§The twin of Ser.



NANGA PARBAT.

AS SEEN FROM A DISTANCE OF 80 MILES.

From a painting by Colonel George Strahan, R.E.



BANDAR PUNCH.

AS SEEN FROM A DISTANCE OF 45 MILES.

From a painting by Colonel George Strahan, R.E.

CHAPTER 2

THE EVOLUTION OF GEOGRAPHICAL NAMES IN THE HIMĀLAYA.

The ancient monuments of India are preserved by the Archaeological Survey; they tell us of the history and arts and thoughts of peoples who lived and died in bye-gone epochs. The Survey of India has in its keeping similar monuments of the past in the shape of geographical names. Ancient buildings and coins appeal to us through our sight and our touch, ancient names impress us by their sound and harmony with their surroundings.

Names such as Himālaya and Kailās are ancient monuments that bear comparison with the stone pillars of Asoka and with the ruins of Ayodhya and Delhi. Names like Gangotri and Badrīnāth are reminders of the courage and enterprise of the Aryan pilgrims who were the first explorers to penetrate the Himālayan gorges and passes. The nomenclature of the Himālayan basin of the Ganges, with its rivers and shrines and peaks and towns, is a remarkable example of Sanskrit art. The name Indus is a relic of the Persian invasion of India in the reign of Darius the Great, 24 centuries ago. The name Hindu Kush has come down to us from Alexander the Great. The name Takht-i-Sulaimān was probably brought to India from Samarkand by one of the Mughal emperors.

Languages are the basis of geographical names, and languages have their origin in history; and thus it is that geography and language and history are all parts of one whole.

Every geographer in countries like Kashmīr, or Western Tibet, or Nepāl or Sikkim, where different races and religions are in contact, finds it necessary to understand the histories of the peoples. Some such knowledge is required to enable him to escape from the bewilderment with which his mind becomes oppressed; without such knowledge he is unable to apply the advice of travellers or linguists to the uses of geography. Before dealing, therefore, with questions of nomenclature I am introducing here a brief outline of historical events that either have, or may have influenced the geographical names. This outline is divided into two tables, one for the Western Himālaya and the western half of Tibet, the other for the Eastern Himālaya and Eastern Tibet.

Historical Table showing the dates of important events in history which may have influenced the nomenclature of the Western Himālaya and Western Tibet.

3000 to 2000 B.C.—Invasion of India by the Aryans who migrated from Persia through Afghānistān. Mongolians from China settle in Western Tibet.

1500 B.C.—In the Mahābhārata and the Rāmāyana references are made to many geographical names such as Kailās, Sindhu, Mānasarowar, Kasmira.

---

570 B.C.—The doctrines of Buddhism are preached in India.

---

521 B.C. (*The Persian Empire*).—The conquest of the Punjab by the Persians under Darius the Great. The names Indostan, Hindu, Indus (corruption of the Sanskrit Sindhu) date from the Persian Empire.

---

450 B.C.—Herodotus mentions Tibetans established in Western Tibet, and Dards in Gilgit. The Afghān name Pathān has been traced in Herodotus (Stein).

---

327 B.C. (*The Greek Empire*).—The Greek invasion of India under Alexander the Great. The Greeks adopted many Sanskrit names, but changed their pronunciations and spellings.

---

321 B.C.—Chandragupta King of the Punjab.

---

260 B.C. (*The Buddhist Empire*).—The Empire of Asoka extends over India and Afghānistān.

---

240 B.C. to 600 A.D.—Buddhism spreads from India into Tibet: Kailās and Mānasarowar, sacred to the Aryans, became sacred to the Tibetans.

---

997 to 1007 A.D.—Invasions of India by Mahmūd of Ghazni. Arab geographers begin to visit India.

1200 A. D. (*The Mongol Empire*).—Gengkis Khan founds the Mongol empire, with his capital at Karakorum; he conquers Central and Western Asia and invades India.

1294 A.D.—Hindu rulers of Kashmīr are replaced by Muhammadan.

1332 to 1342 A.D.—Ibn Batūta visits India, and writes his travels.

1398 A.D. (*The Tartar Empire*).—Invasion of India and Kashmīr by the Amīr Tīmūr.

1526 A.D. (*The Mughal Empire*).—The Mughal Empire of Delhi is founded by the Emperor Bābar, who was descended from both Gengkis Khan and Tīmūr.

Muhammadan writers introduce many modern Persian names : these must not be confused with the old Persian names that date from Darius.

1531 A.D.—Mirza Muhammad Haidar at the head of a Muhammadan army from Kāshgar crosses the Karakorum pass, conquers Little Tibet and invades Kashmīr.

1586 A.D.—Muhammadan rulers of Kashmīr are replaced by the Emperor Akbar.

1600 A.D.—The Dards (Aryans) of Gilgit-Hunza and the Tibetans of Balti become Muhammadans. The countries then become known by the Persian names Dardistān and Baltistān.

1756 A.D.—Kashmīr conquered by the Afghāns under Ahmad Shāh Durrāni.

1819 A.D.—Kashmīr conquered by Ranjīt Singh, the Sikh monarch.

1845 A.D.—Gulāb Singh, Mahārāja of Jammu and Kashmīr and leader of the Dogras, conquers Ladākh, a Buddhist province subject to Lhāsa ; a year later he annexes Baltistān.

1857 A.D.—Geographical interest becomes focussed upon Western Tibet by Colonel Montgomerie's discovery that the second highest mountain in the world is situated there.

Historical Table showing the dates of important events in history which may have influenced the nomenclature of the Eastern Himālaya and Eastern Tibet.

2000 B.C.—Migrations of Mongolians from China flow over Tibet and into the higher valleys of the Himālaya.

2000 B.C.—Another Mongolian migration from North Burma and Tibet penetrates the Assam Himālaya and the hills of Bhutān, Sikkim and Nepāl.

---

640 A.D.—Buddhism is definitely accepted by Tibet. Shrines sacred to the Hindus "like Gauri Sankar and Gosainthān" become sacred also to the Tibetans. Tibetan shrines become goals of pilgrimage for Chinese and other Buddhist races.

---

750 A.D.—Guru Padma the Sanskrit scholar was called from India by the King of Tibet.

---

800 A.D.—Tibet at war with China.

1250 A.D.—The Mongol empire of Karakorum is extended over Tibet.

1350 A.D.—Rājputs from Rājputāna subdue the Newārs of Nepāl.

1559 A.D.—The Rājputs conquer the town of Gorka in Nepāl.

1700 A.D.—Chinese suzerainty begins in Tibet.

1711 A.D.—First Chinese surveys of Tibet; they gave to geography the names Kentaisse and Chumalhari.

1769 A.D.—The Gurkha Prithwī Nārāyan becomes ruler of Nepāl.

1788 A.D.—Gurkhas from Nepāl invade Sikkim.

1790 A.D.—A Gurkha army invades Tibet.

1792 A.D.—A Chinese army invades Nepāl.

1850 A.D.—The discovery is made by the Survey of India that the highest mountain in the world is situated in the unexplored region separating Tibet from Nepāl.

In tracing the advances of geographical knowledge that have been gained in the high mountains of Asia, a narrator feels impelled to refer to the untimely deaths of explorers like Moorcroft, of surveyors like Basevi, of geologists like Stoliczka, of mountaineers like Mallory, but the task is beyond him. No such record would be just unless it showed the names of their assistants and khalāsis and coolies who have died in the same cause. And even then the list would be limited to our own short age, and would be ignoring the numerous sacrifices of life that must have been made when the sources of the Ganges were first explored by pilgrims.

The Linguistic Survey of India.

In 1927 the volumes of the Linguistic Survey of India were published; they dealt with 179 different languages and 544 different dialects. They were written by Sir George Grierson, an officer of the Indian Civil Service, who had devoted fifty years to this work, and who had been in touch with all the oriental linguists of his time. In the mountains of India, Afghānistān and Tibet there are in use among the peoples 70 different languages and dialects, all of which are dealt with in Grierson's work. As time goes on, the knowledge collected by the Linguistic Survey will become of value to the geographical survey; the new volumes will enable geographers to understand much that was obscure to their predecessors; many of our difficulties will be explained, and many causes of confusion will be removed. As an Appendix to Part I of this Himālayan Geography I have added a synopsis of the Linguistic Survey.

Throughout the Himālayas, Tibet, Pāmirs, and Afghānistān there are no Semitic or Dravidian languages. All the languages of these mountainous countries, with one small exception, belong either to the Aryan or to the Mongolian family. The one exception is Burushaski, an ancient language still spoken in parts of Hunza; Sir George Grierson was unable to classify Burushaski with any one of the great linguistic families. (Burushaski was called Khajunah by Sir Alexander Cunningham in his book *Ladak*, 1854. Colonel Lorimer, who is the authority on the Shina language, is now publishing a book on Burushaski.)

About 3000 B.C. two different races, the Aryan and the Mongolian, began to move towards one another and to converge upon India and Tibet, the Aryans migrating from Persia, the Mongolians from China. They eventually settled down in contact, and their ethnographic boundary can still be traced. In the Western Himālayas (Kashmīr) the well-known pass Zoji La is described by Grierson as "the ethnographic watershed between the Aryan and Tibetan populations." In the Eastern Himālayas (Assam and Bhutān) the Mongolian peoples have occupied all the higher and lower valleys and the outer hills, and the inter-racial boundary skirts the plains. From Kashmīr to Bhutān the ethnographic boundary between Aryan and Mongolian follows an irregular line through Spiti, Garhwāl, Nepāl and Sikkim, the Aryans now occupying all the Himālayan hills

on the Indian side of this line, the Mongolians living on the Tibetan side. As the centuries have passed, the Aryan peoples living in the mountains have become separated into many distinct branches, the Dards of Gilgit and Hunza, the Kashmīris, Garhwālis, Kumaunis and Nepāl Pahāris, but all these races have come from the main Aryan stock. The Mongolian advance from China was composed of three separate migrations; a Tibeto-Burman branch came through Northern Burma into the Assam hills, another Tibeto-Burman branch moved from the sources of the Irrawaddy across Southern Tibet into the higher valleys of the Himālayas behind Nepāl and Kumaun. The third migration consisted of the ancestors of the present Tibetan race: they came from China and settled in Tibet: their settlements extended as far west as Baltistān, and into the higher Himālayan valleys. The Tibeto-Burmans now constitute a long series of tribes separating the Aryans from the pure Tibetans, in Sikkim, Nepāl and Kumaun. The Tibeto-Burman dialects spoken in the Himālayas form a linguistic chain connecting the Tibetan language with the Burmese.

Sir George Grierson writes (in a letter dated February 27th, 1931),

"There can be no doubt that many Tibeto-Burman languages along the southern face "of the Himālaya originally came over the passes from the north. Before the Aryan invasion "the south face of the Himālaya was inhabited by speakers of Munda languages. Then came "the Aryan invasion from the north-west, and the Tibeto-Burman infiltration from the north, "so that nowadays the south face of the Himālaya presents a very curious mixture of lan- "guages."

CHAPTER 3.

GEOGRAPHICAL NAMES THAT HAVE GIVEN RISE TO CONTROVERSY.

(1) The principle followed by the Survey of India has been to accept for geography only such names as are in common use by the inhabitants of the country. There have been two exceptions to this rule, in which cases the scientific requirements of geography have outweighed local considerations. The two exceptions are:—

(*a*) *Mount Everest*, which was the name given to the highest mountain of the world in 18~~65~~56.

(*b*) *Trans-Himālaya*, which was the name given by Sven Hedin to the great mountainous region of Central Tibet in 1908, and which was adopted by the Survey of India in 1931.

(2) The geographical outlook of the Tibetans and Mongols is local: they name their passes and grazing-grounds and water, but not their long ranges. The three following names have been borrowed (one from a province and two from peaks) and have been attached by the Survey to mountain ranges—Ladākh, Kailās, Muztāgh Ata.

(*a*) *Ladākh Range*—this name belonged originally to the province of Western Tibet; it was given by Godwin-Austen in 1884 to the mountain range of Ladākh: the Survey of India unable to devise a better name has adopted the name "Ladākh range," but it has not proved altogether satisfactory, as the mountain range has been found to extend beyond the limits of Ladākh both on the north-west and south-east.

(*b*) *Kailās Range*—Kailās is the name of a sacred peak situated upon a mountain range. In 1820 this name was extended along the range by Moorcroft for fifty miles from the peak. In 1829, Dr. Gerard wrote of "the great "Kylas chain." The name was extended along the same range to a still further distance from the Kailās mountain in 1854 by Cunningham. The ranges of Tibet are long, and any names given to them are liable to require extension. The extension of the name Kailās to a great distance from the Kailās mountain has not been satisfactory. If Kailās had not been so well-known the transference of its name to a long range would have been less objectionable, but Kailās happens to be the best known peak in Asia, and the name is out of place in Western Tibet. The name "Kailās Range" is now, however, well established and there has been no desire on the part of geographers to see it altered. I only refer to the disadvantages of extending the name of the peak to the range, that they may be considered when a similar case arises in future.

(*c*) The name "*Muztāgh Ata Range*" was given by Stein to the range bordering the Takla Makān desert on the west. Stein took this name from

the peak Muztāgh Ata. The range had already been named the Muztāgh Range by Sven Hedin in 1890 (*Through Asia, p. 670*), and had been called by Wauhope the Muztāgh Range in 1906. Stein's name Muztāgh Ata is more distinctive in Turkistān than Muztāgh, and as the Muztāgh Ata range is a relatively short range compared with those traversing Tibet, there will be no reasons for extending the name Muztāgh Ata to such great distances from the peak as have proved inconvenient in the case of Kailās.

(3) The inhabitants of high mountain countries occasionally transfer the names of passes to the ranges, and this is a better system than the transference of a provincial name like Ladākh or of a peak-name like Kailās. When an Asiatic traveller is asked the name of the mountains he has crossed, it is only natural that he should give the name of the pass.

The traveller regards the range as an impediment to his progress, and the pass as a means of surmounting that impediment: the Rattan Pīr pass provides the way by which the Rattan Pīr range can be passed. The following ranges named after passes are believed to have been given their names by Asiatic travellers:—

(1) Pīr Panjāl Range, south of Kashmīr. (Authority—Drew's *Jammu and Kashmīr*, p. 78.)

(2) Rattan Pīr Range, south of Kashmīr. (Drew.)

(3) Karo La in Southern Tibet. (Ryder.)

(4) Karakorum }
(5) Muztāgh } both these names were probably taken from the passes by wayfarers and attached to the range of Western Tibet.

(6) Hattoo Pīr near Nanga Parbat. (General Bruce.)

(7) Bhairav in Nepāl. (Hodgson.)

(8) Langur in Nepāl, used by Jesuits for a mountain, and by Hodgson for a pass. (Hedin's *Southern Tibet*, Vol. III, p. 104.)

(9) The name Chomo Lungma may have been taken by Sharpa Bhotias from the pass Lungma La, and extended to the mountain region above the pass.

The geographical meaning of the word "Tibet".

The highland of Tibet consists of many different tablelands separated by mountain chains. There is no other elevation upon the earth's surface that can be compared with Tibet, and there is consequently no word in geography that describes the protuberant mass of Tibet.

In 1888, Sir Richard Strachey wrote (*Encyclopaedia Britannica, 1888*), "Geographers were convinced of the physical unity of the mountainous region "which extends from longitude 74° to 95°. Tibet is a protuberance above the "general level of the earth's surface, of which the Himālaya and the Kunlun "are the southern and northern borders."

From the earliest times, Tibet has been divided by geographers into Great Tibet and Little Tibet. Great Tibet consists of the central and eastern regions of the highland, and Little Tibet has been the name given to Baltistān. The two names are used in the Āīn-i-Akbari: and Bernier describes the interview of the King of Little Tibet with the Emperor Aurangzeb in Kashmīr. In 1788 Rennell showed both names on his map, and in 1854 Henry Strachey found the two terms in use amongst Tibetans. In his Survey of Western Tibet, 1855-1865, Colonel Montgomerie entered the name "Little Tibet" on his maps, and it is still to be seen on the maps of the Survey of India. This name has a historic tradition behind it, and it should certainly be preserved in geography. Its presence on the maps emphasises the important truth that Baltistān forms part of Tibet.

It would perhaps have not been necessary to discuss here the geographical meaning of Tibet had it not been for a difference of opinion that arose in 1930. In June of that year, a paper was read before the Royal Society upon "the "Geographical Representation of the Mountains of Tibet," and it dealt particularly with the alignment of the Karakorum mountains from western to central Tibet (*Proceedings of the Royal Society, Series A, Vol. 127, June 2nd 1930*). In the following August the editor of the "Geographical Journal" in criticising this paper contended that it could not refer to Ladākh, or to the Karakorum mountains of Baltistān, because it was referring to Tibet and to the Tibetan population. He went on to say that Colonel Montgomerie, who made the surveys of Ladākh and Baltistān, "was not concerned at all with Tibet."* These statements unaccompanied by any explanation could only mean that Ladākh and Baltistān are not parts of Tibet and that their populations are not Tibetan. The question is one of scientific importance. The editor has been confusing geographical Tibet with political Tibet, and such confusion can be avoided if due regard is paid to the context. Geographical Tibet embraces the whole highland protuberance stretching, as Richard Strachey said, from longitude 74° to 95°, and including Ladākh and Baltistān. Political Tibet denotes the country under the Government of Lhāsa; the political boundary of Kashmīr separates Ladākh and Baltistān from Tibet.

Geographers are not responsible for this difficulty and they have to meet it with understanding. The mountain mass was named Tibet long before political boundaries came into existence. The Arab Istakhri mentioned Tibet in 590 A.D. Ibn Khurdaba mentioned it in 880 A.D., and Marco Polo used the name. In 1820 Ladākh was under Lhāsa, and Moorcroft the first European explorer, regarded it as part of Tibet. The difference between geographical and political Tibet was introduced in 1846, when the Mahārāja of Jammu and Kashmīr annexed Ladākh and Baltistān. The annexation did not alter the physical unity of the protuberant mass of Tibet, nor did it affect the ethnographic boundary of the Tibetan race.

*Compare Sven Hedin, Southern Tibet, Vol. VII, p. 208, "Montgomerie, the greatest authority of his time on Western Tibet."

In 1854 Henry Strachey wrote as follows, "The north-west extremity of "all Tibet comprises the modern provinces of Ladākh and Baltistān. I consider "Tibet to be terminated by the southward turn of the Indus towards India."

In 1888 Sir Henry Yule wrote, "Tibet is the vast and lofty tableland of "which the Himālaya forms the southern marginal range, and which may be "said roughly to extend from the Indus elbow north-west of Kashmīr to the "borders of China."

In 1907 the Rev. Francke wrote the "History of Western Tibet"; it is a history of Ladākh and Baltistān. Francke lived for many years in Khalatse on the Indus, and he has been the great authority on the Balti language. In his history, he writes that "the political boundary between western Tibet and "central Tibet is the Lahri stream near the Pengong lake." Strachey's definition of Tibet has been hitherto accepted by geographical authorities, from Sir Clement Markham to Sven Hedin.

When the editor of the "Geographical Journal" denies that the population living south of the Karakorum range in Baltistān and Ladākh is Tibetan, his view conflicts with the ethnological authorities; and this question of the population is not even dependent upon the political boundary. That the Ladākhis and Baltīs are Tibetan was shown by Cunningham in his book on Ladākh, 1854; it was clearly shown by Drew in his race map of 1875; it has been corroborated by Grierson in his Linguistic Survey of India, 1927; he writes, "the Zoji "La Pass is the ethnographic watershed between the Aryan and Tibetan "populations."

In the latest edition, 1930, of the Encyclopaedia Britannica, under the article Ladākh the following explanation of Tibet is given:—

"The adjoining territory of Baltistān forms the west extremity of Tibet, whose natural "limits here are the Indus (from its abrupt southward bend in Long. 74° 45′ E.) and the moun-"tains to the north and west separating a peaceful Tibetan population from the fiercer Aryan "tribes. The ethnological frontier of Tibet coincides with the geographical one."

The Imperial Gazetteer regards Baltistān as part of Ladākh, but includes both in Tibet. It says, "Ladākh is the most westerly province of the high "mountainous land spoken of as Tibet. The Karakorum range forms the north-"ern boundary as far east as the Karakorum Pass,........Baltistān is known as "Little Tibet."

In the case of every important mountain alignment of the world, a single name has been used throughout its length to show its physical unity. It would be a mistake to limit the name Tibet to the political boundary and to separate the western end of the highland from the central portion. Geography forms a basis for geology and meteorology, and these sciences are concerned with the Tibetan highland as a whole.

Mr. Sherring's work on "Western Tibet and the British Borderland" is clearly referring to political Tibet: Mr. Francke's history of "Western Tibet"

clearly refers to geographical Tibet. If the two meanings of the name Tibet are found in the future to be inconvenient (and this has not happened hitherto) it will possibly be advantageous to retain the name Tibet for geographical purposes and to accept the name Bodyul for the country governed from Lhāsa. Sir George Grierson writes (*Linguistic Survey, III (1), 14*). "Tibetans call their "country Bodyul, and their language Bodskad; a Tibetan is Bodpa."

Many writers have experienced a difficulty in deciding whether to describe Tibet as a tableland or as a plateau: it consists of many tablelands and many plateaux. In 1886 Sir Henry Yule wrote, "Objections have been raised to "the application of the word tableland to so rugged a region of inequalities, but "it is a technical expression in geography applicable to a large area which is at "all parts at a considerable height above sea-level." Yule, however, quotes with sympathy the British soldier who said in Abyssinia, "Call this a tableland? "then it's a table with the legs uppermost."

During the last half century, geographers seem gradually to have been adopting the British soldier's view in preference to Yule's. There is now a growing tendency in writers to refer to Tibet as a highland.

The meaning of the word Bhotia.

In the last century there was a belief in the Survey of India that Bhotiās, some of whom had taken service in the Survey, belonged to a race intermediate between the Aryan and the Tibetan. But ethnologists have shown that there is no such intermediate race. In 1854 Sir Alexander Cunningham, who knew the districts of Lahoul and Spiti, wrote "Bhotiās are a branch of the great "Mongolian race."

Mr. C. A. Sherring of the Indian Civil Service in his book on "Western "Tibet and the British Borderland," 1906, has given a description of the Bhotiās of Kumaun: "The Bhotiās are of Tibetan origin," he writes, "though they "themselves have the belief that they were originally Hindus." Sherring also says that the Bhotiās are becoming Hinduised, that they add Singh to their names, and that whilst some understand the Tibetan language, others speak Tibeto-Burman dialects.

The following quotation is from Atkinson's Gazetteer of the Himālayan Districts, 1886, Vol. III:—"It cannot be doubted that the Bhotiyas are of "Tibetan origin. They do not admit their Tibetan origin. They state they are "a Rājput race who dwelt originally in the hill provinces south of the snowy "range, and that they migrated to Tibet whence after a residence of several "generations they again crossed the Himālaya and established themselves in the "districts which they now inhabit. The Bhotiyas have however lived so long "amongst and mingled so much with the Tibetans that they possess no claim to "be recognised as of Indian origin. All Bhotiyas unite in assumptions of superi-"ority to the natives of Tibet."

Sir George Grierson does not enter upon ethnological questions: he writes only from the linguistic point of view. He says that Bhotia means Tibetan, a Bhotia is a Tibetan, and that the Bhotia language is the Tibetan language.

General Bruce in his book "Twenty Years in the Himālaya," refers to Sharpa Bhotiās. Grierson states that a Sharpa Bhotia is a Tibetan who is living in Nepāl.

The Name Trans-Himālaya.

Trans-Himālaya was the name given by Sven Hedin to the high mountain region of Central Tibet which he discovered and explored in 1906-08. It had been believed prior to 1906 that long mountain ranges traversed Tibet from west to east. It had been known too that the Karakorum and Kailās ranges which were compressed together in Western Tibet were diverging widely from one another further east, but since the exploration of Nain Singh in 1875 it had been conjectured that the space between these ranges would consist principally of plateau land. The discovery by Sven Hedin that an interior zone of Tibet, 100 miles in width and stretching from longitude 80° to 90°, was a labyrinth of high mountains came as a surprise. The Himālayan range and the Ladākh range had been traced by geographers as curved alignments of high peaks from west to east, but Trans-Himālaya had no such marked crest-line. Its high points did not follow any linear arrangement, and Sven Hedin was thus unable to call it a range. He named this area Trans-Himālaya.

The discovery of Trans-Himālaya has raised the scientific problem of its relationship to the Karakorum range on the north and to the Kailās range on the south. It has also given rise to a difficult problem of nomenclature. When Sven Hedin arrived in Simla from Tibet in 1908, he gave a public address upon his explorations and he announced his intention of designating the newly discovered mountains of Central Tibet by the name of Trans-Himālaya. His lecture was published in the newspapers of India. It is difficult for a reading public to appreciate the details of new and complicated explorations, but it is easy for them to grasp the significance of a new name. They were less interested in the discussion on mountains than they were in the new name. This was very unfortunate. Sven Hedin's explorations had been so arduous and so important that they deserved cordial and generous recognition, but public opinion in India took exception to the name Trans-Himālaya. It would have been better if Sven Hedin had allowed his geographical discoveries to be slowly appreciated and understood, before he had introduced the name Trans-Himālaya. A geographical name is not only a matter of scientific convenience; it has also its sentimental and artistic sides. The Survey of India and the public in India held the view that the mountains of Central Tibet ought to be given a Tibetan name; they thought it unfair to force an Indian name with a Latin prefix upon

the Tibetan people. In the case of Mount Everest, the mountain was standing not in Tibet, but on the Nepāl-Tibet boundary and had been fixed from India. Trans-Himālaya was in the middle of Tibet.

Twenty-three years have now passed since Sven Hedin found his new name opposed in India. The necessity of finding a scientific name for the Trans-Himālayan region of Tibet has of late years become urgent. Frequent endeavours have been made to find a Tibetan name, but they have all ended in disappointment. Tibetan scholars and travellers have been consulted, but none has been able to suggest the ideal name that has been awaited. The Survey of India has thus been led to recognise the force of Sven Hedin's arguments, and to accept the name Trans-Himālaya which he introduced.

Sven Hedin's great work "Southern Tibet", published in 1917 in nine volumes with numerous maps and panoramas, constitutes in itself a complete library of Tibetan geography. Throughout the course of these volumes the student's admiration is aroused both by the accurate, painstaking research and by the fairness and generosity with which the exploratory surveys of all former geographers have been combined together into one geographical history. Sven Hedin writes; "I have done my best not to forget or overlook a single traveller "or scholar from the remotest times to our own days",—and this claim is completely justified. Volume I opens with a generously-worded dedication to the Survey of India, and Volume IV gives an account of Trans-Himālaya and of the orographical problems which its discovery has presented.

The Hindu Kush.

The origin of the foreign name Hindu Kush for the mountain range of Afghānistān has been a source of controversy. Ibn Batūta, the Muhammadan traveller, wrote in 1334 A.D.;—"The mountain is called Hindu Kush because "so many slaves, male and female, brought from India die on the passage of "this mountain owing to the severe cold and snow." Sir Aurel Stein has expressed his disagreement with Ibn Batūta's explanation.

In 1504 the Emperor Bābar wrote in his Memoirs, "Between Balkh and "Kabul is interposed the mountain Hindu Kush, the passes over which are seven "in number."

In 1793 Major Rennell, Surveyor General of Bengal, explained that the term Hindu Kush was probably a corruption of the name Indian Caucasus used by the Greeks during the invasion of India by Alexander the Great, and by Greek historians. Sir Henry Yule agreed with Rennell.

In 1904 in his book "India" Sir Thomas Holdich wrote that the Hindu Kush chain owed its name to the fact that a Hindu force was lost in its attempt to cross into Turkistān by a pass now known as the "Dead Hindu." In 1931 Rennell's explanation is generally accepted.

The question has been raised at times whether the Hindu Kush should be regarded as one range or two; it has two parallel crest-lines. Sir Thomas Holdich wrote in 1906, "The Afghāns regard the Hindu Kush as one mountain "range, but geographers regard it as two. The proximity and parallelism of the "two ranges certainly lead us to think that both are parts of one upheaval. "Geologists have told me that a wide flat-topped range, as the Hindu Kush "originally was, frequently has its top composed of softer rock than its walls "and that the soft top becomes excavated by drainage; a longitudinal river "thus becomes developed between the two walls, and these latter then appear "as separate ranges."

Mount Everest.

The name Mount Everest is now firmly established and definitely adopted: there is no question of changing it ("*Mount Everest: The Reconnaissance.*" *1921: page 13*). But the controversies over the various local names that have been suggested for the mountain have an historic interest. Such controversies are apt to recur, and it is useful to surveyors who find themselves involved in them to know how their predecessors acted and to what extent the decisions taken in the past have been justified by time. There are, moreover, other reasons why these controversies should be recorded in a Survey book. The Survey of India is meeting with difficulties in the geographical nomenclature of Tibet, and the sidelights thrown upon the general question by local controversies are often illuminating. There are difficulties in Tibetan nomenclature that have not been encountered in Afghānistān or in Burma. Survey names require to be fixed, but Tibetan names are often vague and cloudlike. The spelling of survey names is based upon pronunciation, but Tibetan names are not spelt in accordance with pronunciation. Another difficulty arises from books of ritual and the writings of Lāmas. These books vaguely refer to mystic geographical names and the latter are quoted by linguists. Geographers, however, cannot accept them until they have found them in use amongst an influential section of the local population. There are in Tibetan literature thirteen different names for the river Ganges, but they are not in local use. Two English sportsmen who crossed the Jelukhaga Pass into Tibet in 1911 were accompanied by Tibetans through all the high valleys of the Himālayas. They found that the Indian river names Bhāgīrathi and Jadhganga were used by the Tibetans, even amongst themselves, for the tributaries of the Ganges. The Lāmas who made the map of Tibet in 1711 showed geographical names which are not in modern use. Mr. Van Manen learnt of six names applied in a book of Tibetan ritual to the six peaks surrounding Mount Everest, but they were subsequently found to agree with the six names that Colonel Morshead had heard applied by Tibetans to the peaks of Gauri Sankar. If it had not been for the accident that Morshead, linguist and surveyor, had visited Gauri Sankar, the Survey might

have been pressed to apply the names to Mount Everest: and our position would have been a weak one, for the book of ritual seemed unanswerable. Mr. Macdonald learnt from an official at Lhāsa that the Tibetan name of Mount Everest is Mi-ti Gu-ti Cha-pu Tong-nga, but this name was not heard by the Mount Everest expeditions.—See Sir Charles Bell's letter, page 12, *Professional Paper No. 26, Survey of India,* 1931.

Sarat Chandra Das gives in his dictionary (p. 450) Jomo-Gans-Dkar as "a Tibetan name for Mount Everest." Sarat Chandra did not hear the name locally applied to Mount Everest: he learnt it in Lhāsa. The name is not known locally. Ryder and Wood, when viewing Mount Everest from South Tibet, did not hear it. The probable meaning of this name, like that of others, is that it is "a Tibetan name that might be suitable for a high mountain, if any "name for it was wanted."

The Lāma of Rongbuk Monastery (near Mount Everest) has recently written his biography, which may in future be quoted as a geographical authority. Mr. Van Manen has kindly translated page 46: "In the southern part of La-stod "there is the interior part of Phaduk Gyarnorong where there is a mountain called "Jomo-Langma which is the place of religious practice of Mi-gyo-glang-bzang-ma, "who is one of the five sisters Tshering-chenga." Can this sentence be regarded as evidence that Jomo Langma is the Tibetan name for Mount Everest? The Lāma says that Jomo Langma is a place of religious practice: the other geographic names he mentions belong to the peaks of Gauri Sankar (*Survey of India, Professional Paper No. 26, 1931: p.. 9*).

The Lāma does not himself regard his biography as a geographical treatise, for he looked upon the Mount Everest expedition as too mundane to be given space in a spiritual book. (*The Statesman, Calcutta, January 1, 1931.*)

Of the first Everest expedition he merely wrote, "A party went up the mountain: although they stopped there twenty days, they failed to reach the summit and returned without causing trouble." The Lāma relates how some porters were killed on the last Mount Everest expedition, and how the chief Sahib sent a message with money asking for blessings upon the deceased: he writes, "I performed the service with zeal, thinking in my mind how these souls had "suffered, and all for the sake of nothing."

Mr. Van Manen has summed up the difficulties of Tibetan geography as follows:—

> "Geographical observation, local knowledge and a knowledge of the language have to "be brought together. Hitherto the three sources of information have remained apart. "The ritualistic Tibetan who reads mystical names in books cannot identify them with "geographical features. Not all Tibetans in one neighbourhood identify the peaks in the "same manner. The geographer may be misled by synonyms or by information from igno-"rant porters."

Sarat Chandra Das, who was always interested in geography, obtained from the authorities at Lhāsa a list of "the twenty most important mountains in all Tibet." His list was as follows :—

1. Thanlha.
2. Tise.
3. Man-mkhar.
4. Bule.
5. Star-sgo.
6. Pho-la.
7. Mkhahri.
8. Jomo kha-nag.
9. Rdo rye.
10. Gans-bzan.
11. Ptse-rdum.
12. La-phyi.
13. Tshe-rin.
14. Sna-nam.
15. Te-sgro.
16. Hod-se gan-rgyal.
17. Yar-lha cam-po.
18. Gsal-tje.
19. Ha-bo gans-bzan.
20. Tsa-ri na-lahi-gans.

These twenty names have some appearance of geographical reality, for the second name evidently denotes Kentaisse (Kailās) and the thirteenth name is Morshead's name for Gauri Sankar. The twelfth name is said by Sarat Chandra to belong to a mountain (Lapchyi) standing north of Everest—compare Howard Bury : *Mount Everest*, p. 326. Name No. 7 is probably Chomo Lhāri, and No. 1 may be Nyenchen-tang-lha.

The Devadhunga Controversy.

When in 1855 the Surveyor General, Sir Andrew Waugh, first suggested that the newly discovered highest peak should be named Mount Everest, Mr. Brian Hodgson, who had been Political Officer in Nepāl for many years, intimated to scientific societies that Waugh had been mistaken and that the mountain had a local name, Devadhunga. Hodgson was a scientist of high reputation ; not only was he distinguished as an ethnologist and as a naturalist, but he had made profound studies of the different languages in vogue in Nepāl. In 1927 Sir George Grierson in the "Linguistic Survey of India" wrote, "The first attempts "at classifying the mass of Tibeto-Chinese languages were made by Brian "Hodgson, *clarum et venerabile nomen*, and his works still form the foundation "of all similar undertakings. Hodgson's classification holds good for the "entire field of Himālayan philology." The case of Brian Hodgson shows that a good linguist may be an unsound geographer. When Hodgson attempted to identify his mountain Devadhunga with Mount Everest, Colonel Waugh wrote as follows : "Mr. Hodgson endeavoured to establish the identity of Mount Everest "with Devadhunga. His arguments were so palpably conjectural, resting on "hearsay evidence alone, that I thought it needless to refute them as their "fallacious character was apparent to any person competent to understand the "subject. The true geographical latitude and longitude of Devadhunga are "unknown to Mr. Hodgson, or even its true bearing and distance from any "locality. Its height also is unknown. All these elements are necessary "for the identification of that mountain. The appearance of a mountain is an

"uncertain test, but even that test is wanting in Mr. Hodgson's case as he has "never seen Devadhunga. The sketch map published by him gives his idea of "that part of the Himālayas; a more erroneous impression was never formed. "He represents a solitary mountain occupying a vast tract. This single "mountain, however, is entirely imaginary."* Mr. Hodgson replied as follows: "Colonel Waugh may be assured that his Mount Everest is far from lacking "native names, and I will add that I should venture in any case of a natural "object occurring in Nepāl to furnish the Colonel with its true native name, "nay, several (for the country is very polyglottic), upon his furnishing me "with the distance and bearings of that object, although neither I nor any "European had gone near it."

This difference of opinion, of idea and of outlook between Waugh the surveyor and Hodgson the linguist, is of interest even now: the two men were irreconcilable.

Summing up the controversy from a geographical point of view, I have only to draw attention to the following facts:—in 1904 Captain H. Wood visited Nepāl, and observed the principal peaks and consulted all the Nepālese authorities on the subject, and he did not hear the name Devadhunga mentioned. In 1907 surveyor Natha Singh surveyed the Nepālese slopes of Mount Everest and he did not hear the name Devadhunga. General Bruce when in Nepāl did not hear it, nor did the Mount Everest expedition, nor did the recent Nepāl survey expedition.

The explanation of Hodgson's action probably is, that he had learnt the name Devadhunga from Nepālese literature and that he regarded it as a mystic name suitable for Mount Everest. We can, however, sympathise with the Surveyor General, scientific and precise in all his work, when he declined Hodgson's offer of any number of names for any mountain.

The Gauri Sankar Controversy.

In 1855 Hermann de Schlagintweit, a scientific observer of high repute, undertook a mission to India at the instance of the King of Prussia and with the concurrence of Lord Dalhousie. The new peak of Mount Everest had lately been discovered and Schlagintweit determined to observe it himself from two different directions, that is from Sikkim and from Nepāl. He was pursued by ill fortune: when he tried to observe Mount Everest from Sikkim, the peak of Makālu was standing in the way and this peak was so high and impressive that Schlagintweit mistook it for Everest. It was Makālu that he drew as Everest both in his panorama of the snows, and in his well-known landscape picture now preserved at the India Office.

When he moved to Nepāl and tried to observe Mount Everest from Kaulia, the most prominent peak in that direction was Gauri Sankar, and now for the

* Proc. R. G. S. Vol. I., p. 345; quoted by Sven Hedin in "Southern Tibet," Vol. III, 105.

second time he was misled. When drawing his panorama from Kaulia he overlooked the real Everest peak, and he wrote "Everest" against the Gauri Sankar peak. As a geographer Schlagintweit was superior to Hodgson: he was an accurate observer and draftsman. From his drawings General Walker, who had succeeded Waugh as Surveyor General in India, was able to prove by trigonometrical calculations that Mount Everest had not been shown in Schlagintweit's panorama and that the peak which he marked "Everest" was the Survey peak XX, height 23,440 feet. It had not been possible for the Survey to combat the vagueness of Hodgson by means of calculations, but Schlagintweit's panoramas were so accurate that the Survey was able to superimpose their own observations upon his drawings, and they thus discovered his error in the identification of Mount Everest.

Indian geography owes much to Hermann de Schlagintweit, and it has been a misfortune that his errors should have had unceasing attention from controversies, and that his more valuable contributions should have been silently absorbed and forgotten.

Schlagintweit was a Himālayan pioneer, and in his time mountaineers had not realised that the Himālayan problems were different from those of the Alps. They had not realised the immensity of the Himālayan area, nor the countless ranges of innumerable peaks obscuring one another. If Mount Everest had been standing on the Alps, it would have been visible from Switzerland and Italy. And when Schlagintweit saw Makālu standing in the direction of Everest and surpassing all its neighbours in height, he assumed without doubt that it must be Everest, and his assumption was not unreasonable. Schlagintweit's assumption was wrong, but it taught a useful lesson and it brought home to observers how easy it is to mistake one peak for another when they are confronted by a whole sea of peaks.

Mr. Freshfield continued the Gauri Sankar controversy after General Walker had settled the questions in dispute. In March 1903, he wrote in the "Geographical Journal" as follows:— "The reason for which the surveyors argued so "strenuously forty-five years ago that the 29,002 ft. peak could not "be the Gauri Sankar of Nepāl was, of course, that their chief's proceeding in "giving the mountain an English name was excused or justified at the time by "the assertion that it had no local or native name." The surveyors whose motives Mr. Freshfield impugned were formed into a committee in 1859 to consider the question of the identity of two peaks. From geographical evidence available, they concluded that the two peaks were not identical, and their conclusion has been found correct.

In 1903 Captain Wood visited Kaulia by order of Lord Curzon. He found that Mount Everest and Gauri Sankar were different peaks thirty-six miles apart, and that the imposing peak of the snowy range, known to the Survey as peak XX,

was the famous Gauri Sankar of the Nepālese. He also discovered that Everest, far from being conspicuous, was almost obscured from view by intervening ranges.

Chomo Lungma.

In his book "Twenty years in the Himālaya" published in 1910, General Bruce wrote that he had heard the name Chomo Lungma applied to Mount Everest by Bhotiās in Nepāl, but he did not press for its adoption. It was not heard again by European geographers until 1921, when the expedition under Colonel Howard Bury made the first attempt to climb Mount Everest. In the official passport given to Howard Bury, the name mentioned was Chama-Lung, which has a different meaning from Chomo Lungma. In 1926 Sir Sven Hedin published at Leipzig a book on Mount Everest, in which he pointed out that the Lāmas who made their survey of Tibet in 1711 had entered the name Tchoumou Lancma on their map of the Mount Everest region. The problem of this Tibetan name was considered in a Professional Paper of the Survey of India, published as No. 26 of 1931, and the conclusion was reached that some such name as Chomo Lungma is in use by local Bhotiās and applied to a mountain region.

When the Survey were observing the Nepāl peaks from the plains of India in 1849-1855, they designated Mount Everest by the symbol XV; the peaks which they designated XIV and XVI were lower peaks standing twenty miles south of Mount Everest, and both these peaks XIV and XVI were named Tschamlang by the Survey.*

The prefix Chomo is very common in North-eastern Nepāl and the adjoining part of Tibet: we find Chomo Lhari, Chomo Kankar, Chomo Uri, Chomo Tsering. The word Lungma without Chomo is also one of the commonest names in Tibet. In some of the survey maps of Western Tibet the name Lungma occurs forty or fifty times in a single sheet. (See Atlas quarter sheets, 45 N. W. and 45 N. E.). It is also attached to glaciers like the Chogo Lungma, and to passes like the Lungma La, twenty miles east of Mount Everest, and the Lungma La between Abor and Tibet (*Record Vol. IV, 1914, p. 66*). When the new survey sheets of Ladākh and Baltistān were being compiled, it was decided to drop the word Lungma as being too frequently used in Colonel Montgomerie's atlas sheets and as being more probably a noun than a name. The best service which explorers will be able to do in future is to teach the Tibetans to adopt the name Mount Everest.

The Kānchenjunga Controversies.

Kānchenjunga is the mountain of Sikkim, and Sikkim is the name given to the Himālayan area which is drained by the river Tīsta. The population of central Sikkim forms part of the Tibeto-Burman race, and they speak a language

* The higher of the two appeared as Chamlang in Table V of the first edition of this paper, 1907: it appears as peak Chamlang in Table V of the present edition.

known as Lepcha: the Linguistic Survey gives 35,000 as the number of Lepcha speakers. The northern portion of Sikkim is peopled by a section of the Tibetan race, the Sikkim Bhotiās, and they speak a dialect of Tibetan known as Da-njong-ka (20,000 speakers). In the lower hills and terai the Bengalis predominate, whilst the population of the Darjeeling district is largely Nepālese. The following names are given to the mountain of Sikkim:—

People.	Name.	Authority.
Lepchas	Kong Lo Chu	Waddell.
Nepāl Bhotiās	Kang-chen	Hodgson.
Sikkim Bhotiās	Khambu-Karma	Sandberg.
Nepālese tribes	Khumbh-Karan Langur	Hodgson.
Tibetans of Sikkim	Gans-chhen-mdzod-lnga *	Van Manen.
Indians	Kānchenjunga	Imperial Gazetteer and Surveyor General.

It may be thought that the people of Sikkim should be allowed to name the mountains of their country, and that other races should accept their decisions. This rule holds good in the case of local objects such as minor peaks, valleys and towns, but when a mountain is so high as to be visible for over one hundred miles beyond the Sikkim borders, the trans-border populations will have their own names for it also. For centuries the people dwelling in the hot plains of Bengal have been observing with wonder this peak of snow on their northern horizon. The inhabitants of Tibet may have been observing the same peak, but not with the same admiration, as their country is cold, and they have snow peaks on all their horizons.

Along the ethnographic frontier of India we find certain mountains that have both Sanskrit and Tibetan names:

Kailās (Tibetan, Kangrimpoche).
Gurla Mandhāta (Tibetan, Memo-nam-nyim-ri).
Gosainthān (Tibetan, Shisha Pungma).
Gauri Sankar (Tibetan, Trashi-Tsering).

These ancient Sanskrit names were given by Hindu pilgrims to snow mountains situated near shrines of sanctity, and in a later era the same mountains have become goals of Buddhist pilgrimage and have received Tibetan names.

Kānchenjunga, the mountain of Sikkim, is the only instance of the same name, or almost the same name, being adopted by both the Indian and Tibetan peoples.

* The written form of the Tibetan name: the colloquial equivalent is Kang-chhen-dzo-nga.

There has been a controversy over the Sanskrit and Tibetan names—as to which of them originated first. It is possible that both the Sanskrit and Tibetan names have been evolved side by side, not in conflict but in mutual help: it is possible that both forms have now become deserving of preservation through their separate growths, for growth and evolution are more important than origin. Tibetan linguists have rejected the Sanskrit origin of the name, but the supposed Tibetan origin itself is not free from uncertainty.

The following is a brief outline of the history of the geographical name Kānchenjunga :—

1711.—Chinese Lāmas made a map of Tibet, upon which they showed the mountain Chomo Lhāri: they also showed the high mountain of Sikkim, but gave it the name of Rimo-la.

1828-1836.—Klaproth published Chinese maps of Tibet, which have been eulogised by Markham and Sven Hedin. Klaproth showed the Sikkim mountain but gave to it the name Djimoula. His maps corrected the mistakes of the Lāmas in the positions of the mountain and of the town of Phari. (For Klaproth's maps see Sven Hedin's *Southern Tibet,* Volumes I, II and VII.)

1847.—The Survey of India fixed the great Sikkim mountain by observations taken from the plains of Bengal and the outer hills. The Survey officers were British with Bengali assistants. They gave the name Kangchanjunga (so spelt) to the mountain. This was the first appearance in geography of the now famous name and *it came from the side of India.* The Tibetan surveys of the Sikkim mountain were made 135 years before the Indian surveys, but the fact is clear in history that the name came from India and not from Tibet.

Professor Suniti Kumar Chatterji writes that though the Bengali surveyors may have been mistaken, yet they were firm believers in the Sanskrit name when they gave it to the Survey in 1847. Their view was accepted also by Bengali writers, and there are thus over eighty years of usage in Bengali for the Sanskritised form. From Bengali the Sanskrit form has spread to Hindi and other Indian languages.

The professor was writing of the historic period since 1847; but when I see the interest taken in the Himālayan snow-peaks of Nanda Devi and Dhaulāgiri by dwellers in the plains of India, it seems inconceivable that the inhabitants of northern Bengal should have had no name, during the pre-historic centuries, for the peak of perpetual snow which was presenting such a strange contrast to their own hot climate.

1854.—Sir Joseph Hooker brought the name to the notice of the European public in his "Himālayan Journals." Although in his map he used the name

Kangchenjunga in keeping with Waugh's survey map, yet throughout his book he spelt it as Kinchinjunga. He was therefore responsible for the first divergence in spelling.

1857.—Brian Hodgson, the Nepāl linguist, drew his map of the Himālayas and showed the high mountain of Sikkim as Kangchen but without the termination "junga."

1867.—The Survey published a map upon which the name was spelt Kantschin-dschinga. From 1847 to 1867 no spelling had been laid down by authority and every map-maker followed his own ideas.

1872.—The Hunterian system of transliteration was accepted by the Government of India. The right of individual opinion was taken away, and a system of uniformity was introduced. The Imperial Gazetteer was to be issued as the authority and arbitrator.

1881.—When the Gazetteer was first issued the Sanskrit spelling Kanchanjanga was introduced by Sir William Hunter. Unfortunately Hooker's journals were more widely known than the Imperial Gazetteer, and Hunter's decision was not generally accepted. The 11th edition Encyclopædia Britannica gave Hooker's anglicised form Kinchinjunga as preferable, and Hunter's form Kanchanjanga as alternative. In subsequent editions of the Encyclopædia the form Kinchinjunga alone has been given. Constable in 1893 adopted Hunter's Sanskrit form.

Fullarton's Gazetteer and Lippincott's Gazetteer, 1906, adhered to Hooker's form Kinchinjunga.

1882.—Although Hodgson had heard Tibetans use the name Kangchen it does not appear that the full Tibetan name Gans-chhen-mdzod-lnga (or Kangchhen-dzo-nga) ever came into geography through surveyors or explorers learning it from Tibetans in the field. It seems to have been a theoretical name introduced in 1881 by Dr. Jeaschke when he was compiling his Tibetan dictionary. It was introduced to give a Tibetan explanation of the Indian termination "junga." Dr. Jeaschke's theoretical name has had wide influence during the last fifty years, its form and spelling have been accepted at Lhāsa, and are spreading through Tibet. There is no objection to his version being accepted for Tibetan maps. The Bengalis may possibly have built their name Kanchenjunga upon the Tibetan foundation Kangchhen, but the Tibetans may also have derived their termination mdzod-lnga from the Bengali termination "junga."

1900.—When the Secretary of State gave his assent to the Hunterian system, he suggested in his despatch that "some extension should be given to that "part of the scheme which permits a departure from the new system in the case "of those places of which the names have acquired a widely recognised mode of "spelling, either from popular custom or in consequence of historical notoriety."

At the beginning of the present century, when the new edition of the Imperial Gazetteer was being prepared, Kanchenjunga was included amongst the names falling under the Secretary of State's despatch, and two forms of spelling now became permissible. The primary form was Hooker's anglicised Kinchinjunga, and the alternative spelling was the Indianised form Kanchenjunga. The official arbitration thus allowed two different spellings, and this step has given rise to the idea that the question of spelling has not been finally decided.

1903.—In 1903 the Survey of India issued a new map of Sikkim, which was compiled from data supplied by the Quartermaster General; and on this map they spelt the mountain name as Kangchenjunga. This departure on the part of the Survey from the Imperial Gazetteer was probably due to the divided responsibility for this map. The Sikkim map was issued when Colonel Gore was Surveyor General. Colonel Gore was always firm in his support of co-operation and uniformity, and I am convinced that he never authorised the spelling Kangchenjunga.

1904.—Sir Thomas Holdich adopted Kanchanjanga in his book "India" and Mr. Freshfield published his book on "Kangchenjunga." The latter adopted the spelling employed in Colonel Gore's 1903 map. Mr. Freshfield was thus justified in his action. Other mountaineering authors have followed Mr. Freshfield in using the spelling Kangchenjunga. But it is a spelling that does not meet with general approval, for it combines the Tibetan sound Kang with the purely Indian termination "junga." In 1910 General Bruce adopted "Kinchenjanga," an Indianised form.

1931.—The Surveyor General (Brigadier Thomas) has recently made a new appeal for uniformity by abandoning Hooker's form of spelling and by introducing the Indianised form Kānchenjunga into the Survey. It is to be hoped that his action will meet with co-operation.

The spelling "Kānchenjunga" is not an exact reproduction of the Sanskrit form Kanchanjhanga, but no objection can be raised on this account, for the modern Hindu spellings of Gauri Sankar, Dhaulāgiri, Gosainthān, and Kedārnāth are not exact reproductions of the ancient Sanskrit. But the spelling "Kānchanjunga" would have been equally suitable.

The form Kānchenjunga is one of the two forms that have always been permitted by the later edition of the Imperial Gazetteer, and it differs in only one letter from the spelling adopted by Sir William Hunter in the first edition. It is not a Tibeto-Indian compromise.

The spelling Kānchenjunga was moreover adopted as the correct Indianised form by the two most prominent Indian authorities on Tibetan names, Colonel Waddell and Sarat Chandra Das, C.I.E. In his Tibetan dictionary, 1902, Sarat Chandra Das accepted the form Kānchenjunga.

In recent years the Times newspaper in its accounts of Kānchenjunga expeditions has supported the authority of the Imperial Gazetteer and has adhered to the form Kanchenjunga.

The Tibetan Name for Kānchenjunga.

The question of the Tibetan name for Kānchenjunga is surrounded with difficulties. Geographers are dependent upon the advice of linguists, and whilst they have sincere admiration for the knowledge of the latter, they are at times disquieted to find that the linguistic aims and ideas differ from their own. Waugh discovered this in his discussions with Brian Hodgson (see page 23, Chapter 3).

The fact that the written Tibetan name differs materially from the colloquial name is a source of geographical trouble. The written Tibetan name for Sikkim is Hbras-Yongs, the colloquial Tibetan name is Denjong (Bell). The chief authority on the Tibetan language in India is Mr. Van Manen: and when Herr Bauer the leader of the 1929 expedition asked Mr. Van Manen's advice, the latter replied that the correct Tibetan spelling for Kānchenjunga is Gans-chhen-mdzod-lnga, but that as Herr Bauer was writing a book of travel and not a scientific treatise, he might adopt the colloquial spelling Kang-chhen-dzo-nga.* (*Bauer: Im Kampf um den Himalaja.*)

The name Gans-chhen-mdzod-lnga seems to have originated from the difficulty that linguists had in finding a Tibetan equivalent for the Indian termination "junga." The Tibetan name Kang-chhen had been undoubtedly derived from the Sikkimese. The three letters nga in Tibetan mean five, but even then it was difficult to explain "junga." So Dr. Jeaschke introduced mdzod-lnga in place of junga, and mdzod-lnga means "five repositories." The whole Tibetan name Gans-chhen-mdzod-lnga thus meant "the five repositories of great snow."

In the learned note that Mr. Van Manen wrote for Herr Bauer, he explained that when Dr. Jeaschke introduced into his dictionary of 1881 his now well-known Tibetan spelling "Gans-chhen-mdzod-lnga, the five receptacles of the vast glacier ice," he added also an alternative version "Gans-chhen-rje-lnga,

* Maps are scientific documents used in international agreements: the correct form of spelling in preference to the colloquial is invariably adopted on the maps of the Ordnance Survey of Great Britain.

meaning the five kings of the vast glacier ice." To a linguistic enthusiast seeking for an explanation of the Indian "junga" the introduction of two different versions may seem natural and scientific, but to the geographer, who wants to know what the people themselves say, the introduction of two different explanations seems to detract from the value of both.

The different versions suggested by linguists for the Tibetan name of Kānchenjunga may be summed up as follows :—

Name.	Meaning.	Authority.
Gans-chhen-mdzod-lnga . .	Five receptacles of vast glacier ice.	Jeaschke, 1881.
Gans-chhen-rje-lnga . .	Five kings of vast ice . .	Jeaschke, 1881.
Gans-chhen-rtse-lnga . .	Five great glacier peaks .	....
Kang-chhen-dzo-nga . .	Five repositories of great snows.	Waddell, 1891.
Kang-chhen-dso-nga . .	Five treasure chests of great snow.	Sandberg, 1895.
Gans-chhen-mced-lnga . .	Five brethren of great snows .	Ribbach, 1929.
Gans-chhen-mdzod-lnga . .	Five receptacles of vast glacier ice.	Van Manen, 1931.
Kanchen-junga, (Indianised, from the Sanskrit).	Golden thigh	Imperial Gazetteer.

It will be seen from this table that the termination has been a source of trouble to Tibetan linguists. No Tibetan substitute for the Indian "junga" has been agreed upon. The variety of the attempts to find a substitute is an indication of uncertainty.

Colonel Waddell has explained that "the five repositories of great snow," mean the five peaks of Kānchenjunga; other writers have said that they mean the five glaciers. But the word "five" seems out of place applied to Kānchenjunga. As applied to Gauri Sankar it had a meaning, for Morshead found five similar sister peaks standing in juxta position. But Kānchenjunga is an immense pyramid, and only one side of it can be viewed at a time. The Lepchas have truly named it "the high screen of snows," for it screens everything behind it. The geographer has a right to ask, why should Kānchenjunga be called "five peaks" or "five glaciers;" six peaks or ten or fifty would be equally applicable. The word five has no explanation in the topography. It has been said that when we view Kānchenjunga from Darjeeling, we see five promi-

nent peaks. But the Tibetans dwell to the north-east of the mountain, and Darjeeling is situated to the south-west. Why should Tibetans invent a name to suit a foreign aspect of the mountain? Darjeeling is now a popular hill-station, but a hundred years ago it was only a Lepcha town. Its name is Lepcha.

If we consider the peaks that stand in the vicinity of Kānchenjunga, Jonsong is a Tibetan name, but Kabru and Jano are names not used by Tibetans (Bell). Pandim is a Lepcha name, and Narsing is an Indian names. In Chapter 22 which describes the Tīsta river a note has been included, in which it is shown that the Private Secretary to the Maharajah of Sikkim does not agree with the view that the name Kānchenjunga has been derived from five peaks or five glaciers or five treasuries of snow.

I feel sure that linguists will realize the uncertainty that has been experienced by surveyors who have had to decide upon one definite form of spelling. Linguists have looked upon the name Kang-chhen-dzo-nga as though it were a Lhāsa Tibetan name, but it was a Da-njong-ka name used only in Sikkim. Whether this name is of ancient or recent standing in Sikkim cannot be discovered, but that it has only recently been recognised in Lhāsa seems certain. In Sikkim the Tibetans constitute a small minority of the population.

The following letter from Sir Charles Bell, who was the political officer in Sikkim, illustrates the difficulties with which surveyors were confronted when they were conversing with the hill people. "The Sikkimese," he writes, "do "not as a rule use the whole word Kang-chhen-dzo-nga, but more often simply "Kang-chhen. A great many apply the name Kang-chhen to the other mountain "Kabru, because throughout a great part of Sikkim Kabru is the more conspicuous mountain of the two. Kang-chhen is not a well-known Tibetan mountain; for every Tibetan who knows Kang-chhen five hundred will know Chomo "Lhāri."

The original meaning of the Sanskrit name was "the mountain of the golden thigh," the word golden having reference to the effects of sunrise and sunset upon the mountain. Geographers see with surprise that Colonel Waddell, the linguistic authority, became annoyed with the Tibetans of Sikkim when he found them accepting the Indian idea in preference to his "five repositories of great snow." In his book "Among the Himālayas," 1900, p. 386, he writes, "Kānchenjunga is called by Tibetans the repository of gold. This name it "seems to me has arisen from the interpretation of the popular name in too "literal and mythological a manner. The name Kānchenjunga is Tibetan and "means literally the five repositories of the great glaciers and it is physically "descriptive of its five peaks."

It is possible that these Tibetans obtained their ideas of gold from the Indian name "golden thigh." The Sikkim manual of worship for the mountain god

speaks of a treasury of gold, the lofty peak being gilded by the rising and setting sun.

For maps of Tibet the name regarded as authoritative by Van Manen in 1931, namely Gans-chhen-mdzod-lnga, should I think be accepted: but for maps of India Kānchenjunga should be retained.

Even if the Indian and Tibetan names have emanated from one origin, they have followed different courses of evolution. Hitherto we have been trying to force the two names by compromises into one spelling. It will be better in future to recognise that the two names have diverged so widely in their growth that they cannot now be both represented by one and the same formula. In accepting two forms of spelling we shall be recognising them as two different names and shall be treating them as we treat the Indian and Tibetan names for Kailās and Gauri Sankar.

The Sanskrit Name Kancan-jangha.

A surveyor has to learn the pronunciation of geographical names from the people and to convert them into written words. An etymologist is interested in discovering the ancient origins of names. Prudent surveyors refrain from trespassing upon the etymologists' ground. In 1835 the explorer Vigne ventured to explain the origins of certain names in Kashmīr, and he has been held up as a warning to trespassers. His case is quoted by Sir Aurel Stein as showing that a geographer may be a bad etymologist. (*Ancient Geography of Kashmīr.*) The Sanskrit origin of the name Kānchenjunga has been explained by Mahamahopadhyaya Dr. Hara Prasad Shastri as having been "Kancan- jangha," the golden thigh. The spelling of the name, he says, according to the Geneva Convention adopted by all Sanskritists throughout the world, is Kancana-jangha, (for ordinary purposes Kancan-jangha).*

The objection has been raised that the shape of the mountain bears no resemblance to an inverted thigh, that the mountain has a pointed summit whereas a thigh (cut off at the knee) does not terminate in a point. From Purnea in Bihār, however, Kānchenjunga has the appearance of being a high point on a jagged ridge; the following passage is quoted from Colonel Tanner's report, 1883—"Kabru (24,002 feet) is connected with the second peak of Kān-"chenjunga (27,803 feet) by a ridge, the lowest depression of which has an alti-"tude of 22,100 feet".

The Sanskrit name Kancan-jangha may have been given to the mountain by pandits in comparatively recent times, like the name Nanga Parbat in Kashmīr. No etymologist has claimed that the Sanskrit name Kancan-jangha is of great antiquity.

A further note on the name Kānchenjunga has been added in Appendix 3 of Part III of this book, in reply to certain criticisms of the name, that have been published in the Himālayan Journal of 1932.

*Himālayan Journal, III, p. 154.

The Karakorum controversy.

The length of the Karakorum range has been proved by Sven Hedin to be so great, that it will be found advisable for geographical purposes to subdivide it into sections, as has already been done in the cases of the Alps, the Rockies, the Andes, and the Himālayas. In all these ranges the mountain names have been preserved throughout their lengths, and the sectional names have been taken from the countries which the ranges traverse or border. The Andes have been subdivided into the Chilian Andes, the Peruvian Andes, and the Patagonian; the great Himālayan range has been subdivided into the Punjab Himālayas, the Kumaun Himālayas, the Nepāl and the Assam. The Punjab Himālayas are the Himālayas seen from the Punjab and drained by the Punjab rivers: they contain the "Punjab Hill States". The Hindu Kush are divided into the Afghān Hindu Kush and the Chitrāl Hindu Kush. If we adhere to this world-wide precedent and to this approved geographical method,—and I do not think that we can improve on it,—we shall subdivide the Karakorum into—

(1) the Hunza Karakorum,
(2) the Balti Karakorum,
(3) the Depsang Karakorum, and
(4) the Tibetan Karakorum.

The question whether the Karakorum range should be regarded as one great range or as two parallel ranges does not affect the fundamental nomenclature; if we look at such a problem from a synthetic point of view, we can hardly avoid the conclusion that the main Karakorum crest, the Masherbrum ridge, and the watershed range are component parts of one orographical whole. But if the details are examined from an analytical point of view, it may be found convenient to distinguish the separate parts by different names. It is always advisable to begin with synthesis and to limit the analytic process as much as possible. The question of analysis will be considered in the second part of this book.

A controversy has however at times arisen over the *name* "Karakorum," and in this chapter the question is being considered whether the name Karakorum could with advantage be replaced by Muztāgh (or by Muztāgh-Karakorum, *vide* Geogr. Journ., April 1927, p. 327; also Sept. 1929 and August 1930). All along the frontiers of India the names of passes are well known, and the names of passes, as I have already pointed out in this chapter, come to be transferred to the mountain ranges. The two passes over the Karakorum range have been known for centuries as the Muztāgh and the Karakorum, and it has been only natural, as was pointed out by Drew in 1875, that both these names should have come to be applied by travellers to different parts of the same range, the name Muztāgh on the west of Baltistān and the name Karakorum on the east. Both these pass-names are foreign names, but as I have also

shown in this chapter, the pass-names over our trans-frontier ranges generally do spring from the foreign languages spoken beyond them. And thus it has come about that although the mountain names of Baltistān. such as Gasherbrum, Baltoro, Chogo Lungma, Rimo are all Tibetan, the two pass-names are both Turki. I see no objection to this: the Tibetan pass-names Zoji La and Lipu Lekh and the Afghān pass-name Khaibar are quite well known to Indians, and the Turki pass-names Muztāgh and Karakorum are known to Balti Tibetans.*

When scientific maps are being prepared, geographers find it inconvenient to have two names applied to the same mountain range within a relatively short distance of one another. Our predecessors found it unnecessary to describe the range as the "Muztāgh or Karakorum," and so the responsible authorities, Sir Clements Markham in London in 1871 and General Walker in India in 1876, decided to drop the name Muztāgh and to apply the name Karakorum to the whole range. William Moorcroft in 1820 was the first European explorer to introduce the name "Karakorum mountains." In 1831 Grimm's map showed "Karakorum Gebirge" along the northern bank of the Indus. In 1830 and 1844 Humboldt gave the name Karakorum to the central range of the Tibet plateau, and Humboldt's authority has been recognised by the geographers of Europe (*Sven Hedin: Southern Tibet, VII, XXXII*). Humboldt applied the name Muztāgh to the Tien Shan range, on the authority of the Emperor Bābar's memoirs. In 1854 Alexander Cunningham and Henry Strachey made surveys of Western Tibet: Cunningham wrote that he found Moorcroft absolutely trustworthy and one of the most conscientious men that ever lived. Strachey wrote that he owed almost all his nomenclature to Moorcroft. In a recent paper Sir Aurel Stein has lamented that no biography has been written of so great a geographer as Moorcroft (*Life of Theodore Duka, 1914*). The story that Moorcroft travelled to Lhāsa had no foundation: he sacrificed his life in his enthusiasm for geographical exploration, and he was at Andkhui, north of the Hindu Kush when he died.

In 1855-1865 Colonel Montgomerie made his survey of Western Tibet and determined the heights and positions of the Karakorum peaks: he gave to his peaks the symbol K after the name Karakorum. In his reports he sometimes referred to the Karakorum range and sometimes to "the great range which is "called both Muztāgh and Karakorum". His assistant was Captain Godwin-Austen, who wrote two papers on the glaciers of the Muztāgh range: the glaciers which Godwin-Austen described were those near the Muztāgh section of the range and there was no significance in his reference to the Muztāgh range. On his grave near Guildford are engraved the words, "He surveyed the Kara-

*The Turki speaking people of Kāshgar are Mongolians and are closely related to the Baltis. The latter are the only Tibetans who have forsaken Buddhism and become Muhammadans: their conversion was probably due to the influence of Mongolian Muhammadans from Kāshgar.

"korum Range." The name Karakorum Range was definitely adopted for the maps of the Government of India in 1876.*

In 1907 I referred the question of the name to Colonel Wauhope, who was an oriental scholar, and who had passed his career in the mountains of the north-west frontier, and who had only recently been surveying the Pāmirs and Hindu Kush: he wrote in reply—"Muztāghs are as common all over Central Asia as "Safed Kohs on our north-west frontier. The name Karakorum is quite "established now for the mountain range separating the Indus and Zarafshān, and "is the most suitable."

If the name Karakorum was considered more suitable than Muztāgh in 1876, its superiority has been enhanced during the last fifty years by the modern application of the name Muztāgh to other high mountains. It has been said that the name Karakorum is as common in Turkistān as the name Muztāgh. In Stein's list of the geographical names of Chinese Turkistān the name Karakorum only appears twice outside the Karakorum range, and on neither of these occasions is its use of any geographical significance. (*Memoir by Sir Aurel Stein; Record Volume XVII, Survey of India.*) If we take a generalised fundamental map like Stein's map of Chinese Turkistān, published by the Royal Geographical Society (*scale $\frac{1}{6M.}$, Geographical Journal, May 1925*), we see that beyond the Karakorum range there are only three mountain names of sufficient importance to be entered on such a map, and they are—

(1) Muztāgh Ata peak, (on the Muztāgh Ata range),
(2) Kungur,
(3) Muztāgh peak, (on the Kunlun range).

Two out of these three primary mountain names are Muztāgh; and there is also the Muztāgh Ata range; if we had three high mountains in Europe all named Mont Blanc, the confusion would become intolerable. We ought therefore to avoid any further extension of the name Muztāgh as a primary mountain name in Asia; and we ought to adhere loyally to the decision of Moorcroft, Markham and Walker, and to uphold the fine distinctive name of Karakorum.

The Karakorum Pass.

The Karakorum Pass is famous in both the history and the geography of Asia. It has been said that this pass is not on the Karakorum range. It is not on the crest-line of the range, but it is a pass over the range. A range is not a single line, it is a massive fold of rock, one hundred miles wide, that has been raised up out of the earth's crust. The fact that the Shyok river has cut its way back through the southern flank of this range and through its crest-line to the

* In 1862 the Schlagintweit brothers adopted the name "Karakorum Range," *vide* Sven Hedin's *Southern Tibet*, III, 169. In 1875 Stieler adopted Karakorum, and gave the name Muztāgh to the Kāshgar range. Subsequently Sven Hedin applied the name Muztāgh to this Kāshgar range, and Sir Aurel Stein has called it the Muztāgh Ata range. The application of the name Muztāgh to this Kāshgar range renders the name Muztāgh undesirable and unsuitable for the Karakorum range.

Karakorum pass is a phenomenon that has many parallels in Asia. In their book on the Karakorum glaciers, Dr. and Mrs. Visser show how the Hunza and Gilgit rivers have cut back through the Karakorum crest; what has occurred in Hunza has occurred also in Depsang. The Karakorum range, the Karakorum watershed and the Karakorum pass form a scientific triad of names, and their triple accordance impresses upon us the lesson that the range, the watershed and the pass are parts of one geographical whole. (This question will be considered in greater detail in Chapter 14 of Part II.)

The meaning and history of the name Karakorum.

The word Kara means black, and Korum means fallen rock or gravel. It has been suggested that it is not suitable to apply a name meaning black to a snow-mountain. Muztāgh means snow-mountain, but this name has already been used too frequently to be any longer distinctive. The name Kara-Kul, black lake, is said by Hedin and Wauhope to have originated from the sudden storms which break over it. Dr. Visser has written that he sees no objection to a name meaning black being used for a snow-mountain, and I do not think that the original meaning of a word as used in conversation should be literally considered, when it has been compounded with other words into a geographical name. There is a Himālayan river named the Kāli Ganga (Black river) and another the Dhauli Ganga (White river): both these rivers have dark depths and both have cataracts of white foam; their two names are in artistic contrast and are scientifically distinctive, and it would be wrong to test them by literalism.

Colonel Wood has been a strong supporter of the old name Karakorum. Referring to the Karakorum pass in 1922, he raised an interesting question, but without any desire to introduce a change. He wrote,—

"It is difficult to understand why this pass received the name Karakorum, which means "black rock: the formation is red sandstone and the most noticeable colour is yellow".

If therefore the name Karakorum is unsuitable for a white mountain, it is equally unsuitable for a yellow and red pass. Yet it would be indeed ridiculous to change the name of this historic pass, a name known for centuries to the peoples of Asia. Colonel Wood's note led me to study the history of this pass and of its name. Dr. Arthur Neve wrote (*Thirty Years in Kashmīr, 1913*: quoted by Sven Hedin in *Southern Tibet*), "The trade route over the Kara-"korum pass has been used from time immemorial. Rock inscriptions show "that it was used centuries before the Christian era. Chinese armies have "swept over it, and for centuries the Chinese held fortified posts along it. Indian "conquerors have defied climatic difficulties, and have established colonies on "the north side in the basin of the Tārīm".

In the 13th Century, Gengkis Khan the Mongol, who ranks as a military leader with Caesar and Napoleon, conquered the greater part of Asia and the

south-eastern part of Europe: his empire extended from Pekin to Warsaw. If we go through Central Asia to-day, we are told that three men have conquered the world,—Alexander, Gengkis Khan and Tīmūr (*Lamb's History of Tamerlane*). Gengkis Khan founded the Mongol empire, and his capital city (now in ruins) was Karakorum in Mongolia. From the city of Karakorum Asia was governed, and the name Karakorum was known everywhere. The Imperial road from Delhi to Karakorum passed through Kashmīr and Ladākh, and crossed over the pass now known to us as the Karakorum. In England we speak of the "London road," and the "Bath road:" in India we talk of the "Agra road" and the "Lahore road." At Delhi itself we have the "Kashmīr Gate." In Ladākh to-day they say the "Leh road." Is it not likely that in the days of Gengkis Khan the people spoke of the "Karakorum road?" And their "Karakorum road" from India crossed the pass which to-day we call Karakorum. The culminating point of the long road from Delhi to Karakorum was the point we now name "Karakorum pass." I venture to submit that history has furnished the explanation of our geographical name Karakorum, which could not be learnt from the colour of the rocks.

When Dr. Neve wrote the passage which I have just quoted from him concerning the "Chinese" armies sweeping over the pass, and the "Chinese" fortified posts, I think that he must have been referring to the Mongols. Kublai Khan, the grandson of Gengkis Khan, moved the Mongol capital to Pekin and ruled over Tibet.

Alexander the Great was accompanied on his campaigns by historians: Julius Caesar was his own historian. The mausoleum and mosques of Tīmūr are still reverenced at Samarkand: the letters of Napoleon are preserved in the libraries of Europe. But no memorial of Gengkis Khan is to be seen in Asia.

The name of Gengkis Khan's capital Karakorum has, however, during the progress of geography in Western Tibet, come to be bestowed in the 19th century upon the highest mountains of his Empire. And it is in this way that geography has provided the memorial which archæology had failed to do.

The recent introduction of double names.

In 1927 a proposal was made to substitute new double names in place of the old simple names, that had become so well known. The following table gives the old names and the new proposals:—

	Existing names.	*Double names proposed.*
The Main Range .	Karakorum	Muztāgh-Karakorum.
The Mountain Region .	Karakorum	Karakorum-Himālaya.
Outer subsidiary range	Aghil	Aghil-Karakorum.
Inner subsidiary range .	Kailās	Kailās-Karakorum.

At the meeting of the Royal Geographical Society in 1926 when these double names were first proposed, Colonel H. Wood made a protest against them, and he voiced the opinion of Survey officers, political officers, and sportsmen. The double name Karakorum-Himālaya was withdrawn at the advice of Dr. Longstaff, and surveyors felt indebted to him for his generous co-operation (*Geographical Journal, August 1930*).

The double names Kailās-Karakorum and Muztāgh-Karakorum are however being used. Attempts have been made to find precedents for them in the Alps, but there are no precedents there or elsewhere. In the Geographical Journal for August 1930 (p. 142) it was stated that the double name Kailās-Karakorum "is equivalent to the name Bernese Alps." The Bernese Alps are a subdivision of the Alpine Range: the name Bernese merely denotes that the subdivision is on the side of Berne. Kailās is the name given to a mountain range in south-western Tibet, *and Karakorum is the name given to a different mountain range in another province of Tibet.* The name Bernese Alps is a sectional and regional name, and is not the name of a long mountain chain. The name Kailās-Karakorum is not sectional and not regional: it is being proposed for a whole mountain range as long as the Alps. If we want a Balti parallel to the Bernese Alps, it must be Skārdu-Karakorum, for Skārdu is the capital of Baltistān, as Berne is of Switzerland. The name Kailās-Karakorum is a combination of names that geographers should avoid. Kailās is a Sanskrit name that came into Tibet from the south 30 centuries ago, the name Karakorum came into Tibet from the north 7 centuries ago. Both the Sanskrit and Mongolian names have an historic right to their own places in Tibet: but these places are 400 miles apart, and though the Kailās range is being found to approach the Karakorum, it is unwise to combine their names. In the vicissitudes of history anomalies may gain places in geography, but with care no confusion need arise. The double name will carry the name Karakorum into the region of the Mānasarowar lakes, and it will be out of place there.

In the Geographical Journal for August 1930, page 147, the name Muztāgh-Karakorum has again been compared with the names Bernese Alps and Punjab Himālaya. Neither of these comparisons holds good: Muztāgh-Karakorum is the name proposed for a great range that has always been known as Karakorum and that requires no second name; the names Bernese Alps and Punjab Himālaya are applicable to subdivisions only: the meanings of these two latter names are self-explanatory; but the combination Muztāgh-Karakorum has no meaning. (The question which has been raised as to the true *alignment* of the Karakorum range will be considered in Chapter 14 of Part II.)

CHAPTER 4.

NOTES ON CERTAIN IMPORTANT MOUNTAIN NAMES.

(*a*) Himālaya.

(*b*) Southern Tibet.

(*c*) Baltistān.

(*d*) Dardistān.

Himālaya, if not the oldest, is one of the oldest names in geography. The word is Sanskrit and means the abode of snow. During the Greek Empire in India its historians transformed the name into Imaos and Emodus. Alexander Cunningham, 1854, was the first explorer to define Himālaya for the purposes of modern geography. His definition was that the Great Himālaya formed the natural boundary between India and Tibet.

As geographical knowledge progresses it may become necessary to modify or extend an original definition. The two names Himālaya and Tibet represent contiguous mountainous regions, which merge into one another, and it has not been possible to define the boundary line between them with absolute precision.

In his book on Tibet, Sir Thomas Holdich, following Sir Richard Strachey (1880) wrote, "Modern geography restricts the Himālaya to that portion of the "mountainous region between India and Tibet which is enclosed between the "arms of the Indus and Brahmaputra." This definition served its purpose for many years, but in 1913 Morshead discovered the peak of Gyala Peri (23,460 feet) situated on the Great Himālayan alignment outside and beyond the bend of the Brahmaputra, and this discovery obliges us to accept a modification in detail though not in principle of the Strachey-Holdich definition.

In 1904 the surveys of Ryder and Wood in Southern Tibet showed that the whole Tsangpo Valley belonged geographically to Tibet, and in 1908 Sven Hedin confirmed this view: so that the Himālayan-Tibet boundary has now to be retired southwards from the actual line of the Tsangpo river to the small Ladākh range which forms the Nepāl-Tibet watershed. In western Tibet it is not possible to assume the Ladākh range as the geographical boundary, because the Indus is flowing southward of the range. The actual valley of the Indus along its southern bank clearly belongs to geographical Tibet, whilst the highest Himālayan slopes clearly belong to the Himālaya range. The only modification here in the Strachey-Holdich definition that seems in 1931 to be desirable is to place the Himālayan-Tibet boundary upon the Zāskār range, which runs between the Indus river and the Himālayan crest-line and is parallel to both.

The Great Himālaya range exceeding 1,500 miles in length has had to be subdivided for purposes of geography into different sections, and these sections have been named from the countries with which they are associated, in accordance with the geographical precedents of the Alps and Andes. The sectional names are Punjab Himālaya, Kumaun Himālaya, Nepāl Himālaya and Assam Himālaya. These names have been founded upon custom and tradition: they were chosen in 1907 by Sir Henry Hayden and myself in consultation with political and scientific authorities. They have met with general acceptance, and we recommend their continuance. The name Punjab Himālaya had long been recognised in the Punjab Hill States, and it is a bond of union between mountains and plains: the Punjab Himālaya feed all the Punjab rivers from the Sutlej to the Indus, and these same rivers have brought prosperity to the province. The name Sikkim-Himālaya is not a suitable name for one of the main geographical divisions of the Himālaya. Sikkim owes its importance to Kānchenjunga and Darjeeling: the presence of a single mountain, even Kānchenjunga, is not a sufficient reason for a separate classification, and it is more correct scientifically to regard Kānchenjunga as the eastern peak of the Dhaulāgiri-Mount Everest section (see Part I, Charts I to V,) than to classify it as a solitary and independent mountain. The area of Sikkim is small and its population is made up of Tibetans, Lepchas and Nepālese. The name Sikkim is Lepcha. (See Part I, Chapter 3).

NAMES OF HIMĀLAYAN PEAKS.

Nanda Devi and Trisūl.

Nanda Devi (Goddess Nanda) and Trisūl (trident) are ancient Sanskrit names that are attached to Himālayan peaks in Kumaun and Garhwāl. Trisūl has been so named from its irregular summit, and is supposed to resemble a trident, which is regarded by the Hindus as symbolical of the divine triad. The snow-peak of Nanda Devi is an object of veneration to the villagers in the hot plains of Bijnor. At times the wind blows the snow from the peak like smoke, and the people of the plains will say, "The Goddess Nanda is lighting "her kitchen fire." (*Imperial Gazetteer*). Professor F. W. Thomas writes, "It is possible that the mountain of Kumaun was originally known to the Hin-"dus as Nanda, because a mountain of that name is attributed by them in "their cosmography to the Kraunca continent, which probably represents Ku-"maun."

Badrīnāth (Lord of Badri), Kedārnāth (Lord of Kedār = Siva), Gosainthān (Place of a Saint), and Gauri Sankar (The Goddess and her Consort) are ancient Sanskrit names which have been transferred from shrines and attached to neighbouring peaks; the latter thus serve as beacons to the pilgrims who are climbing to the shrines. The name Badrīnāth is mentioned in the Rāmāyana.

Jaonli (Sanskrit) is a peak near the shrine of Gangotri; the snow peak of Bandarpūnch acts as a beacon to pilgrims visiting the shrine of Jumnotri.

Srikānta.

Srikānta is the name of a Himālayan peak standing near the source of the Bhāgīrathi branch of the Ganges. It is a well-known mountain and has been an object of admiration to residents of Mussoorie for generations. There has been a general idea that the name Srikānta must have originated from the Hindustāni word Kānta, which has been supposed to be descriptive of the "sharp point" of this peak. Professor F. W. Thomas, C.I.E., writes, "Srikanta is a designation of Siva, 'glorious throat,' referring doubtless to "his blue neck, which gives him also the name Nilakantha. The word "Sri-Kanta, 'beloved by Sri, (Laksmi)' or 'lovable through distinction' is a "good Sanskrit form, and is actually used as a designation of Vishnu."

Makālu.

The name Makālu is a corruption of the name Kamālu. General Bruce was the first to point out that this name Makālu, the origin of which had been frequently discussed for eighty years, was derived from Kamālung, the name of a local river (*Twenty Years in the Himālaya, 1910*). An officer who was recruiting Gurkhas subsequently confirmed General Bruce. The name Makālu has now an historic place in geography and cannot be changed. Its corruption was involuntary and was due to the surveyors' honest effort to represent the Tibeto-Nepālese pronunciation. The two last letters of the word Kamālung were almost silent in pronunciation, there was no emphasis on the first syllable, and the force of the middle syllable led to the inversion Makālu. General Bruce learnt the name Kamālung from Tibetans. In 1867 Colonel Montgomerie was given the name Sihsur for the peak by Indians resident in Nepāl.

Nanga Parbat.

Nanga Parbat; Sanskrit name, Nagna Parvata, naked hill; or Ananga Parbata, hill of Karna. Nanga Parbat is the Kashmīri name: the regional name is Diamar or Daryāmur or Diamarai (Bruce), and this regional name is applied to the mountain locally. The mountain as seen from India is known by its Kashmīri name. The name Nanga Parbat though of Sanskrit origin is not a name of great antiquity like Badrīnāth or Kedārnāth; it was probably given to the mountain by Kashmīri pandits in comparatively recent times.

Takht-i-Sulaimān.

The Persian name Takht-i-Sulaimān, the throne of Solomon, is attached to a conspicuous rocky hill near the Jhelum in Kashmīr, and also to a mountain (height 11,300 feet) situated beyond the Indus, west of the Punjab. The name

probably originated during the Mughal empire, and this probability gives to it a certain historic interest, because the Mughal emperors did not give names to the mountains of India.

The Hindu temple situated on the Takht-i-Sulaimān in Kashmīr is very much older than the name Takht-i-Sulaimān itself, and the Hindu name of the hill is Gopadri. The Emperor Akbar built a fort upon the Hari Parbat ridge near the Takht, and he probably introduced the name Takht-i-Sulaimān into Kashmīr. The Amīr Tīmūr, one of the "conquerors of the world," was an ancestor of Akbar, and the early Mughal Emperors must have often visited Tīmūr's tomb at Samarkand. In Lamb's History of Tīmūr we read (*Tamerlane, p. 97*), "The Amīr Tīmūr was always glad to see the snow peak, the Majesty "of Solomon, gleaming through the mists that rose from the Amu river." The traditions of Tīmūr were venerated by the Mughals, and when Akbar saw the hill in Kashmīr enveloped by the mists from the Jhelum, he would have recalled Tīmūr's palace on the Amu Darya.

The name Takht-i-Sulaimān is also attached now to the peak that stands to the west of the Punjab; this name is however not in use among the local Pathān tribes who inhabit the Zhob, Wazīri and Baluchi hills; they call the mountain Kaisargarh. The people of the Punjab plains who see "the snow "peak gleaming through the mists" that rise from the Indus know the mountain as the Takht-i-Sulaimān.

MOUNTAIN NAMES IN SOUTHERN TIBET.

Kailās.

The mountain Kailās is famous in Sanskrit literature as the Paradise of Siva. The name Kailās is so old that it is futile now to seek for its origin or derivation. Professor F. W. Thomas writes, "In Sanskrit we do not profess "to know the etymology of Kailāsa, which is found in the Mahābhārata." Sven Hedin has said (*Trans-Himalaya, II*) that Kailās is "incomparably the "most famous mountain in the world: Mount Everest and Mont Blanc cannot "vie with it."

The actual circuit round the holy mountain is about twenty-five miles and occupies three days. Old men and women, Buddhists as well as Hindus make the pilgrimage. ("*Western Tibet and the British Borderland,*" *by C. A. Sherring, 1906*).

The first Europeans to visit Kailās were William Moorcroft and Hyder Hearsey in 1812. They entered Tibet by the Niti pass, called by Moorcroft the Niti Ghāt.

In 1731 D'Anville published his map of Tibet and showed Kailās upon it under the Tibetan name of Kentaisse. This was probably a corruption of Kang-tise. In 1828 Klaproth in his map of Tibet used the name Gang-dis-ri, which may have been a corruption of Gang-tise-ri. In the Tibetan dictionary of Sarat Chandra Das the mountain is called Tise.

In 1904 Ryder gave the Tibetan name as Kang-rim-poche.

In "Southern Tibet," Vol. III, Sven Hedin wrote that the Tibetan Lāmas who now live at Kailās "do not know the name Kentaisse: they call the mountain Kang-rim-poche." This name Kang-rim-poche is also given by Sir Charles Bell, and is now accepted as the Tibetan name.

Gurla Mandhāta.

In 1853 Henry Strachey showed this mountain under the name of Gurla. Richard Strachey gave the name as Gurla (Mandhāta). It is now known as Gurla Mandhāta, and in 1904 Ryder found its Tibetan name to be Memo-nam-nyim-ri.

Gurla Mandhāta is a Sanskrit name and Professor Thomas has given the following etymology:—Gurla is a corruption of Guru Deva, and Mandhāta is the legendary Indian monarch Māndhāta who is famous among both Indians and Tibetans.

Gurla Mandhāta is a sacred mountain of the Hindus and stands twenty miles north of the shrine of Khojarnāth. Although it is the highest peak standing north of the Himālayas in Tibet it does not appear to be regarded by the Tibetans as one of their important mountains.

An interesting description of Gurla Mandhāta and of its surroundings and approaches is given by Mr. C. A. Sherring, I.C.S. and Dr. Longstaff in the former's book on "Western Tibet and the British Borderland."

Riwo Phargyul.

This mountain is of exceptional geographical interest; it is standing in close proximity to the deep gorge which the river Sutlej has cut through the Zāskār range, and by means of which this river escapes from the Tibetan highland.

Riwo Phargyul is not one of the sacred Buddhist mountains, but its name is well-known to the Tibetans. It was introduced into modern geography in 1821 by the explorer Alexander Gerard, who called it, not incorrectly, Mt. Purgeool. In 1863 its position and height were determined by the Survey of India, who discovered it to be a double peak and who gave to it the name of Leo Porgial. Colonel Morshead pointed out in 1920 that the more correct name is Riwo Phargyul, and this latter form has been accepted in this book. Riwo is merely one of the Tibetan forms of Ri, mountain, and Phargyul is another variant of Gerard's Purgeool and the Survey's Porgial. Very little was known of the Tibetan language in 1863, when the Survey made their maps of this part of Tibet. Leo may appear in writing to be very different from Riwo, but the Tibetan pronunciation vacillates between the two versions. Tibetan names appearing upon maps are frequently not in accord with local pronunciations or with the forms given by modern travellers. But it is inadvisable to assume

that the original field surveyor must have been wrong. Different Tibetans pronounce names differently among themselves and at different times, and even the Tibetan linguists of to-day write names differently among themselves and at different times. Questions of nomenclature can only be determined by a qualified and pains-taking enquirer, and as such a man requires a knowledge of surveying and also of different dialects and peoples, he has to possess exceptional mental powers. Our surveyors have occasionally been criticised for their spellings of names when the errors attributed to them have been due to changes in methods of transliteration.

Chomo Lhāri (formerly spelt Chumalhari).

This mountain is with the single exception of Kailās the best known of the mountains of Tibet, not only to the Tibetans themselves but to European geographers. Sir Charles Bell has written (*Tibet: Past and Present, p. 14*) "Chomo "Lhāri, the mountain of the goddess, is devoutly worshipped." Mr. Sherring has written (*Western Tibet*) "a pilgrimage to the three holy mountains, Kailās, "Gauri Sankar and Chomo Lhāri confers on the devotee a virtue which cannot be "excelled."

This mountain was shown on the Chinese Lāma's survey of Tibet in 1711 and upon D'Anville's map in 1733. It was shown upon all Klaproth's maps compiled from Chinese sources, 1828 to 1836. (Sven Hedin's *Southern Tibet, Vol. III.*) Klaproth gave its height as 26,000 feet, a value too great by 2,000 feet. The error in the Chinese estimate of height is evidence of the impressive appearance of the peak and of its conspicuous prominence, standing as it does in comparative isolation.

Namcha Barwa.

This high mountain of the Assam Himālaya was not introduced into modern geography until 1912, when it was observed by Captain Morshead from the Mishmi hills and by Captain Oakes and Captain Field from the Abor country. They determined its height as 25,445 feet. Colonel Robertson had intersected the peak with his plane-table some years before from the Mishmi side but had been unable to fix it. In 1913 Morshead discovered the Tibetan name for this peak, Namcha Barwa, and this name he said means "lightning burning in the "sky".

The discovery of its great height came as a surprise to geographers, who had been led to think that no peaks above 20,000 feet could be standing north of Assam. The inability of the Survey to observe this peak in former years was due to the fact that it had been completely hidden by comparatively high outer ranges from the observers in Assam. Survey parties had not then been allowed to penetrate the outer hills, which formed a continuous wall blocking the

view from the south. It was only owing to the expeditions into the Abor and Mishmi countries which were sanctioned in 1912 that Namcha Barwa came to be observed from two different directions (see Part II, Assam Himālaya). The discovery of its height by Oakes, Morshead, and Field, all officers of the Royal Engineers and of the Survey of India, is the most important advance in Himālayan geography since 1855, when the height of Nanga Parbat was discovered. Of the three discoverers, Capt. Oakes died of wounds received in action in France in 1916, Capt. Field was killed in action in France in 1916, and Colonel Morshead was shot in Burma in 1931.

The discovery of Namcha Barwa and of its great height has led to the prolongation of the crest-line of the Great Himālayan Range for 300 miles. In 1913, one year after the discovery of Namcha Barwa, Captains Morshead and Bailey discovered the gorge by which the Tsangpo river escapes from Tibet through the Great Himālayan range. This gorge had, of course, been known to resident Tibetans for centuries, but the discovery of its exact position had since 1884 been one of the principal objects of geographical exploration in Asia. It was only in 1884 that Kishen Singh definitely proved that the Tsangpo river flowed into the Brahmaputra and not into the Irrawaddy, but Kishen Singh did not discover the place where the river actually left the plateau.

When the first edition of this book on Himālayan Geography was being written in 1907, neither the peak of Namcha Barwa nor the gorge of the Tsangpo had been discovered. The following extract from the first edition is introduced here to illustrate the views that were held in 1907 :—The Sutlej in issuing from Tibet pierces the border range of mountains within 4½ miles of Leo Pargial, the highest peak of its region; the Indus when turning the great Himālayan range passes within 14 miles of Nanga Parbat, the highest point of the Punjab Himālaya; the Hunza river cuts through the Kailās range within 9 miles of Rakaposhi, the supreme point of the range. It will form an interesting problem for investigation whether the Brahmaputra of Tibet has cut its passage across the Assam Himālaya near a point of maximum elevation.

It will be seen that in 1907 the existence of a high peak near the gorge of the Tsangpo was considered probable. The fact that such a peak has now been discovered standing near the gorge tends to confirm the view that the peak and the gorge were closely related in their origin. See the first edition of this book, 1907, part III, pages 159 and 186.

The mountain Namcha Barwa may have been known to the Lāma surveyors of 1711; a temple named Tchamca is shown in the position of Namcha Barwa inside the bend of the Tsangpo in D'Anville's map. D'Anville's drawing shows, however, that the lāmas had no idea that Namcha Barwa was an important mountain. They do not even draw it as a mountain, and they may have learnt of the temple Tchamca from hearsay.

MOUNTAIN NAMES IN BALTISTĀN.

Many of the names in the Karakorum, such as Gasherbrum and Baltoro and Rimo, have given rise to discussions for years: the more they are examined and analysed, the more certain do we become that all these names are Tibetan. This conviction is becoming so obvious that our successors will probably wonder why there should have been any discussion at all. The people who live in the valleys of the Balti-Karakorum are Tibetans speaking a Tibetan dialect (Balti). But there are Turki-speaking races on the north, Kashmīris on the south, Dardic races on the west: the peak of Nanga Parbat was given its name by people living at a distance from it who were regardless of its local name, and it has been felt that the name Gasherbrum may have originated from a distance too. The ethnography and languages of Western Tibet have not hitherto been clearly understood: the facts that the Baltis are Muhammadans and do not conform to the Buddhist fashions in dress and hair have led to the mistaken belief that they are not Tibetans. The conclusion that is being forced upon us is that all the Karakorum names Gasherbrum, Masherbrum, Baltoro, Biafo, Hispar, Siachen, Rimo, and others are Tibetan (Balti dialect).

Fifty years ago the belief was held that the nomenclature of Northern and Central Tibet was Turki. (See Language Map, Tibet, 1880, prepared for the House of Commons: the Turki language is shown extending across Tibet from the Kunlun almost to Kailās and Mānasarowar). Sven Hedin's maps show Tibetan names. This misconception arose because explorers had recruited the head-men of their parties from Turkistān and had relied on them for geographical names. Colonel Montgomerie, when he made his surveys of Western Tibet, was alive to the danger in obtaining Balti and Hunza and Ladākhi names from Kashmīri surveyors. Our experience of his maps has shown that he was eminently successful in his endeavours to derive all geographical names from the local villagers.

The names Gasherbrum and Masherbrum were introduced into geography by Montgomerie in Baltistān. Neither Moorcroft, nor Henry Strachey nor Cunningham showed these names in their maps of Ladākh.

As our understanding increases, we find internal proofs that the Karakorum names are Tibetan: the glacier name Ri-mo is pure Tibetan. In the glacier name Chogo Lungma, the word Lungma is pure Tibetan. The Tibetan name Chomo Lungma has been proposed for Mount Everest. Lungma is entered over fifty times in each of Montgomerie's maps of Western Tibet (Atlas quarter sheets 45 N. W. and 45 N. E.).

Outside Tibet we do not meet with twin names like Gasherbrum and Masherbrum, differing from one another in their initial letters only. In South India we have Bangalore and Mangalore, but these cities are separated by a great distance, and have no connection with one another. Gasherbrum and Masher-

brum are companion peaks: the Baltoro and Saltoro glaciers are both in the Balti-Karakorum. Montgomerie referred also to the Nobundi and Sobundi glaciers. In the Punjab Himālaya we have the Tibetan names for two close companion peaks, Ser and Mer, called also Nun and Kun.

Bishop Peter of the Moravian Mission in Western Tibet has written: "Gasherbrum and Masherbrum have always interested me for their strange "names. One man from Baltistān gave it as his opinion that brum meant "something like the first morning light on a mountain, and the first two syllables "seemed to denote to his mind something like lucky or pleasing. But ety-"mology without a very full knowledge of more than the language is extremely "misleading sometimes. And names of mountains are not at all part of every-"body's knowledge amongst mountain people. They do not come into the "small talk of the villages."

In 1907 Dr. Longstaff gave the name Teram Kangri to a new peak he had discovered in the Karakorum at a place known as Teram. Dr. Longstaff completed the mountain's name by affixing the Tibetan word for snow mountain, namely Kangri.

The Peak K^2.

The highest peak of the Karakorum, named by Colonel Montgomerie K^2 and still known as K^2 had been given no name by the Balti Tibetans. There is nothing surprising in this omission. To them it is merely one of the many points of an immense snowy range, and the fact that it was higher than the other points was unknown to them. The fact moreover that this point was higher than the others would probably not have been of any great interest to them, probably of no more interest than it would be to forest-people to know the highest tree of their forest.

The great altitude of peak K^2 was not discovered till 1856-1858. Colonel Montgomerie first observed the peak from the Kashmīr mountain of Haramukh in 1856. His theodolite tent was at a height of 16,000 feet; as a rule an observer cannot tell at the time of his observations which particular peak is higher than the others, as their relative distances are unknown to him. But the Survey tradition has been that when Montgomerie first intersected K^2 from the summit of Haramukh, he turned to his Indian recorder, who was with him, and said, "Babu, we have shot the giant."

Many names have been proposed for this peak K^2;—Mount Waugh and Mount Albert were considered in 1860; Mount Montgomerie and Mount Godwin Austen were suggested about 1886; Mount Akbar and Mount Bābar were names considered in 1905-06. But none of these names met with general approval in India. So the peak of K^2 has continued to be known as K^2 for 70 years. The unforeseen has now happened.

Since 1860 surveyors and sportsmen have been telling their followers that the high peak is named K^2, and from the followers the name has been filtering

through to the inhabitants. During the last decade explorers have been finding that the Tibetans of Baltistān are turning the symbol K^2 into a geographical name Kaytoo or Kaychoo. The sound of K^2 in English speech may have reminded them of some word or name in their own language. Dr. Francke, the Moravian missionary, has been the leading authority on the Balti dialect of the Tibetan language, and he was a geographical enthusiast (1900-1910). He never mentioned the possible development of such a name as Kaytoo, but he was one of those who used to explain to the people that the Survey called their peak K^2. The name Kaytoo is a product of local evolution, and it possesses originality, a quality that was lacking in the personal names proposed by geographers.

The following extract is from a letter written in 1931 by the Tibetan scholar Dr. Ribbach, who lived for many years as a Moravian missionary in Western Tibet:—

I have to confess my ignorance in the case of Masherbrum and Gasherbrum.

Biafo may be the Balti form of bya-po, the Tibetan for cock.

Rimo is a Tibetan word and means "picture" (also streaks, which may be suggestive of the crevices).

Baltoro may be derived from dpal-gtor-po, the spreader of abundance, which would be suggestive of the glacier, the giver of fertility.

Saltoro would be "gsal-gtor-po," the giver of light, descriptive of the glacier glittering in the sun.

No doubt these names have in the course of time altered in form and sound so much that it is difficult, even impossible, to trace their origin. But often educated natives (in Tibet at least) know the original form and use it in writing. A few examples:—

Leh, the capital of Ladākh, is "slel" in writing.

Shày, a village near Leh, is "shel" in writing.

Lama Yuru, a monastery in Ladākh, is "Lama-gyung-drung" in writing.

Spituk, a well-known monastery, is "dpe-tub," and so the educated Tibetan spells these names quite differently from the pronunciation.

MOUNTAIN NAMES IN DARDISTĀN.

Boyo-haghurdonas (Boiohaghūrduānasir).

Boyo-haghurdonas is a mountain name that was evolved from the Burushaski language. Colonel Lorimer sees in it three Burushaski words:

Boyo = a divine animal.
Haghur = horse.
Donas = one who opens.

The meaning of the united name,—devil—horse—opener,—is not clear.

The Burushaski language has presented an unsolved linguistic and ethnographic problem: it is the only Indian language that has not been placed by Sir George Grierson in one or the other of the linguistic families. Grierson believes that the Burushaski people are a remnant of aborigines, probably Dravidian, who were cut off from the other aboriginal inhabitants of India by the Aryan invasions, and who have found a sheltered home amongst the hills of Hunza for forty or fifty centuries.

Haramosh.

The name Haramosh comes from the Shina language, and Colonel D. L. R. Lorimer writes that the second vowel is long and stressed. There is, however, an emphasis on all three syllables. The name has no connection with the Kashmīri mountain name Haramukh (*Grierson's Kashmīri Dictionary, p. 343*) in which the second vowel is short or lacking (Harmukh). In Kashmīri, Hara is a name of the God Siva and Haramukh means the face of Siva. Colonel Lorimer writes, "The proposal to call the ridge that carries Rakaposhi the "Haramosh ridge is sound. Haramosh is a well-known name, but Rakaposhi "is not. A traveller can always easily ascertain by enquiry where Haramosh "is."

The name Haramosh has been derived from haram = bad, and from mosh = man; but Lorimer considers this derivation to be a worthless popular etymology. "Haram," he writes, "is Arabic for forbidden: Mosh is the Khowār "word for man, and the Khowār language never extended east of Yasin."

Rakaposhi.

Colonel Lorimer writes, "Where this name came from is a mystery. The "Mīr of Hunza used always to twit us, the British, for having invented it. "The correct name of this mountain, as known in Hunza, is Dumani. I "have never been able to imagine that it was a European invention, and I am "quite prepared to believe that it is a genuine native name." The Mīr of Hunza was mistaken in attributing this name to the British. It was introduced into modern geography in 1854 by Henry Strachey, whose geographical names have always been found by subsequent surveyors to be correct. The explorer Vigne introduced the name Haramosh in 1835: Henry Strachey in 1854 showed on his map the three names Haramosh, Rakaposhi and Dubanni. In 1860 Colonel Montgomerie of the Survey of India found all three of Strachey's names known to the inhabitants, and in 1884 Colonel Tanner found the name Rakaposhi to be known in Gilgit. Colonel Tanner painted the picture of this mountain that was published as the frontispiece to Black's History of the Indian Surveys, 1891, and he introduced the idea that Rakaposhi meant Devil's Tail. The tradition grew in the Survey of India that Rakaposhi was a Sanskrit name.

But there was no foundation for this view: Sir George Grierson has written, "Raka may be a corruption of Rakhas, a devil: but if Rakaposhi means devil's "tail, it must only be corrupt Hindustāni, as poshi must be the Hindustāni "pūnch. In Dardistān posh means covering or dress. It looks as if the "meaning Devil's Tail had been invented by a Kashmīri surveyor or clerk."

The following extract is from a letter written in 1930 by Lieutenant G. C. Clark, R. E.:—"Rakaposhi is called Dumani by the people of Hunza and "Nagir, and this means a Necklace of Clouds. Rakaposhi is a name more "used by the people of Gilgit, and is said to be derived from Raka the name of a "lad and from Poshi, a Shina word. The tale goes that Raka was a Gilgiti "from the Bagrot nullah, who was in league with the fairies. Every now and "then he went off with some of them to some distant spot. One day he dis-"appeared and did not return for some time. When he did get back, he told "the villagers in reply to their questions that he had been taken up to the top "of the hill and from there had seen most of the world. Hence the name, which "means in the Shina language Raka's View Point."

There is a general consensus of opinion amongst surveyors and linguists that the name Rakaposhi is a valuable geographical name, and that it must certainly be retained; the tradition of its Sanskrit origin and of its supposed meaning "Devil's Tail" must however be abandoned. The name Rakaposhi is undoubtedly Shina. Colonel Lorimer criticises Lieutenant Clark's etymology on the grounds that Raka is not a Shina name and is not given to lads in Gilgit.

Dubanni.

The third name of the Hunza triplet is Dubanni or Dubunni. There has been a suspicion that this name might have been a corruption of the Shina name Dumani, but investigations have shown that this is not the case. Henry Strachey has been proved right in his adoption of Dubanni. The name Dubanni is quite well-known to the local inhabitants and has been heard in use in the Haramosh district by many surveyors and travellers. It is said to mean a "blanket of clouds," the first syllable "du" being traced to the Shina word "dum" meaning "smoke". But this popular etymology is said by Colonel Lorimer to be mere conjecture.

Kunjut and Hunza-Kunji.

In Tables IV, V and VI of Chapter I three peaks will be found named Kunjut and three named Hunza-Kunji. These six peaks were observed from long distances many years ago. The northern border of Hunza was not then so well-known as it is now: the original observers probably thought that all these peaks were standing upon the Hunza border; we now know that whilst some are situated actually on the border, a few stand inside it, as the Hunza river has cut back through the Karakorum range and forced the Hunza watershed

to retire behind the crest-line of peaks. The name Kunjut (modern spelling Kanjut) is the Central Asian or Turcoman name for Hunza: Colonel Lorimer writes that the name Kanjut is used for Hunza by the Chinese officials. Dr. Neve mentions in his book "Thirty years in Kashmir," 1913, that the village head-men in Hunza told him that the Muztāgh Pass was formerly used by Kanjuti raiders and had to be closed for that reason.

The 3 peaks now named Kunjut do actually stand upon the Hunza border. Montgomerie had in the first instance called them "Trans-Indus," a name suggestive of distance and uncertainty. When it was discovered that they were standing in the Kanjut region, they were re-named Kunjut.

For the other three peaks the name Hunza-Kanjuti would probably have been more correct than Hunza-Kunji; until surveyors have learnt the dialects spoken by a population of mixed races, they are apt to miss syllables cut short in speech, and mispronunciations lead to misspellings. The name Hunza-Kunji denotes the Hunza-Kanjut border, just as in Europe we speak of the Franco-German border.

The peak names Kunjut and Hunza-Kunji have thus been evolved from the intercourse of Indian and Kashmīri surveyors with Dard and Kunjuti residents, there is nothing artificial about these names, and they are distinctive and descriptive. They have been found most useful for many years. The practice of grouping a small number of peaks under one name has been found to be successful in such cases as Gasherbrum and Tirich Mīr.

The Name Hindu Rāj.

In the wild Trans-Indus country south of Dardistān there is a mountain range named Hindu Rāj.

General Bruce has questioned the suitability of this name. General Bruce knows the Himālaya from Sikkim to Dardistān and in his book, "Twenty years in the Himālaya," he has often been helpful in his references to nomenclature and maps. When therefore on a rare occasion he does give way to an outburst of criticism, his words carry weight. General Bruce says that the name Hindu Rāj is hopeless, and he asks, why Hindu? why Rāj? These questions cannot be answered. But their author, under the influence of the mysticism which pervades the mountains, goes on to say that the Hindu Rāj range itself would be annoyed, if it only realised the unsuitability of its name. If however we could consult the range, I feel that it might possibly say to us, "My name Hindu Rāj is a relic of former greatness. Don't deprive me of it. "I once belonged to an ancient kingdom." (Possibly Gandhāra, of Vedic times.) (The Hindu Rāj range is described in Chapter 25.)

NOJLI TOWER.

A STATION OF THE GREAT TRIGONOMETRICAL SURVEY, BUILT IN THE PLAINS OF UPPER INDIA NEAR ROORKEE, AND FROM WHICH THE HIMALAYAN PEAKS OF BADRINATH, KEDARNATH, JAONLI AND BANDARPUNCH HAVE BEEN OBSERVED

From a photo by C D Simons

CHAPTER 5.

ON THE ERRORS OF THE ADOPTED VALUES OF HEIGHT.

(i) The problem as viewed in 1907.

The values of height given in Tables I to VII of this paper must be accepted with caution; some are more reliable than others, but none are correct to a foot, and many investigations will have to be completed before altitudes can be determined with a greater degree of accuracy than at present.

Errors of observation.—All observations are liable to error; no telescope is perfect, no level is entirely trustworthy, no instrumental graduations are exact, and no observer is infallible.

In ordinary triangulation the objects to be observed are sharp and specially erected signals, but for the observations of a high peak, the summit, however ill-defined, cannot be furnished with a suitable mark.

If a flat-topped peak be observed from a near station, the surveyor runs the risk of mistaking some lower point for the summit, the latter being obscured from his view by an intervening shoulder.

Errors of measurement however can be greatly reduced and rendered practically negligible, if a peak be observed with a good theodolite on *several* occasions and from *different* stations; observations of Mount Everest, of K^2, of Kānchenjunga, and of others have been repeated so often and from so many different places that the local angles of elevation have been probably determined within one or two seconds of the truth, and the errors in the mean values of height *due to faults of observation* are probably less than 10 feet. But in the cases of peaks Nos. 19 and 40 of Table IV, and others, which have been observed from one station only and on but few occasions from that, errors due to faults of observation may attain to 100 feet. A single intersection of a peak from a single station deserves no weight whatever: it may give a result hundreds of feet in error.

The adoption of an erroneous height for the observing station.—Heights in the Himālaya that have been measured from one or two stations only may in places be thrown into error to the extent of 10 or 15 feet by the adoption of erroneous altitudes for the stations of observation.

In the case of the Karakorum and Ladakh ranges the liability to error on this account is larger and is perhaps 30 feet; the peaks of the Hindu Kush have been observed from less known stations than those of the Karakorum and are possibly 70 feet in error in consequence.

The Kāshgar range being still more remote from the triangulation of India, the heights of its peaks are less reliable than those of the Hindu Kush; and the peaks of Kungur and Muztāgh Ata may be in error by 300 feet, or even more, on account of the accumulation of error in the assumed altitudes of the stations from which they have been observed.

Variations of snow.—An element of uncertainty is introduced into heights by the fact that the altitudes of peaks are always varying in nature with the increase and decrease of snow. The discrepancies that obtain between the different determinations of height of the same peak may be partly due to the fact that some observations have been made after the snow has been accumulating, and others after it has been diminished by heat, evaporation, wind, and avalanches. All heights on land have to be measured from the surface of the sea, and as the latter rises and falls with the tides, a mean level of the sea has to be adopted: and so in the case of the great peaks, we shall have eventually to assume the mean level of the snow at their summits as the altitude to be determined.

The deviation of gravity from the normal.—A plumb-line is a string supported at its upper end and stretched by a weight attached to its lower end.* If there were no irregularities of matter near the earth's surface a plumb-line would hang truly normal; but mountains exert a lateral pull, and tend to deflect it towards them. In the same way as plumb-lines are pulled out of the normal, so is the surface of water near mountains pulled out of its spheroidal form. The attraction of the great mass of the Himālaya and Tibet pulls all liquids towards itself, as the moon attracts the ocean, and the surface of water in repose assumes an irregular form at the foot of the Himālaya. If the ocean were to overflow northern India its surface would be deformed by Himālayan attraction. The liquid in levels is similarly affected and theodolites cannot consequently be adjusted: their plates when levelled are still tilted upwards towards the mountains, and angles of elevation as measured are too small by the amount the horizon is inclined to the tangential plane. At Darjeeling the surface of water in repose is inclined about 35″ to this plane, at Kurseong about 51″, at Siliguri about 23″, at Dehra Dūn and Mussoorie about 37″.'

No attempt has yet been made to apply corrections to the values of height on account of Himālayan attraction: the determinations of the deflections of the

* To render intelligible references to the deviation of gravity it is necessary to define the following words, *vertical, horizontal, normal, level, tangential.* If the earth had been at rest, it would under the influence of gravity have assumed the form of a sphere: its rotation round an axis has converted the sphere into a spheroid flattened at the poles. The present figure of the earth is not a perfect spheroid, however, as the surface is disfigured by mountains and valleys, which are rigid enough to withstand the influences of gravity and rotation. Everywhere in fact on land we meet with slopes and cliffs that are obviously inclined to the general surface of the earth. Water, however, whether it be in a basin, or lake or ocean, conforms closely to the spheroidal surface, and it is more exact to say that the figure of the sea is a spheroid, than that the figure of the earth is one. The surface of the sea, however, though more nearly spheroidal than that of the land, suffers from slight irregularities, and water in repose does not conform exactly to the spheroid. Continents and mountains attract water towards themselves, and their attraction disfigures the surfaces of oceans and ponds and levels. If the earth were a homogeneous and perfect spheroid, the direction of gravity would everywhere be perpendicular to its surface, but the earth is irregular, and gravity does not always coincide with the perpendicular to the general surface. Gravity acts in a direction perpendicular to the surface of water. We have then to consider what we mean by a *vertical* line—whether it is the perpendicular to the earth's mean surface or whether it is the direction of gravity. The word *vertical,* we think, should be employed to describe the direction of gravity; the line perpendicular to the mean surface should be called the *normal.* The actual surface of the sea and of water, however disfigured from a spheroid, is the *level* surface, and the word *level* should only be applied to this actual surface. The following definitions will explain the difference between the *horizontal* and *tangential* planes at any point of the earth's surface: the *horizontal* is the plane that is tangential to the local surface of water, however the latter may be deformed: the *tangential* plane is the plane that is tangential to the mean spheroidal surface.

plumb-line are at present not sufficiently perfect to justify the results being utilised to correct altitudes. (*Philosophical Transactions of the Royal Society of London:* Series A, Volume 205 (1905), pp. 289 to 318.)

We know that all angles of elevation to Himālayan peaks measured from the plains of India and from the outer hills are too small, and consequently all our values of Himālayan heights are too small. Errors of this nature range from 40 to 100 feet.

Of the deflection of gravity from the normal in Tibet or Kāshgar or on the Karakorum or Hindu Kush we know as yet nothing.

If a peak be observed from different directions, the deflection of the plumb-line in the plane of the peak will probably be different at every observing station, and the several values of height may consequently appear discordant. Such discordances, however, are unavoidable; their presence implies that the direction of gravity has been varying, and it leads us to hope that the errors due to deflections of the plumb-line are tending to cancel in the mean.

Atmospheric Refraction.—The most serious source of uncertainty affecting values of heights is the refraction of the atmosphere. A ray of light from a peak to an observer's eye does not travel along a straight line, but assumes a curved path concave to the earth. The ray enters the observer's eye in a direction tangential to the curve at that point, and this is the direction in which the observer sees the peak. It makes the peak appear too high. Refraction is greatest in the morning and evening and least in the middle of the day: it is different in summer from what it is in winter. If we observe Dhaulāgiri from the plains of Gorakhpur, it appears to fall 500 feet between sunrise and the afternoon, and to rise again 300 feet before sunset. Even in the afternoon, when it appears lowest, it will still be too high by perhaps 700 feet.

In 1853 Sir Andrew Waugh determined the curvature of the path of a ray of light between the outer Himālaya and the low plains of Bengal, by means of simultaneous observations taken from both ends of the ray. He then assumed that the path of a ray to a snow peak would be similarly curved, and he reduced the apparent heights of the peaks accordingly. But we believe now that he reduced the heights by too much: his determination of a ray's curvature in the outer Himālaya was correct, but this curvature, we think, is not maintained at higher altitudes. As the rarefaction of the atmosphere increases, the ray assumes a less curved path, and Sir Andrew Waugh's method attributed to refraction a greater effect than it really has. To the Karakorum heights Colonel Montgomerie employed smaller corrections for refraction than Waugh used for the Himālaya.

Summary of errors.—If we bring together in the following table the different errors to which carefully determined heights of peaks are liable it will help to focus our ideas :—

TABLE VIII.—Magnitudes of possible errors.

Source of error.	Great Himālaya range.	Karakorum range.	Kāshgar range.
Variations of snow-level from the mean	Unknown	Unknown	Unknown.
Errors of observation	10 feet	20 feet	100 feet.
Adoption of erroneous height for observing station	10 feet	30 feet	300 feet.
Deviation of gravity	60 feet, too small	Unknown	Unknown.
Atmospheric refraction	150 feet, too small	10 to 30 feet	50 feet.

Deduction of the height of Mount Everest.—The following table shows how the different values of the height of Mount Everest have been deduced :—

TABLE IX.—Height of Mount Everest.

Station of observation.	Year of observation.	Height of station of observation.	Distance from Mount Everest.	Values of height, if no correction for refraction be applied.	Resulting height as determined by Waugh with co-efficients of refraction varying from 0·07 to 0·08 from stations in the plains.	Resulting height from computations in 1905 with coefficient of refraction 0·05 from stations in the hills.	Resulting height with assumed coefficient of refraction 0·0645 from stations in the plains.
		Feet.	Miles.	Feet.	Feet.	Feet.	Feet.
Jarol	1849	220	118·661	30366	28991·6	..	29141
Mirzapur	1849	245	108·876	30165	29005·3	..	29135
Janipati	1849	255	108·362	30141	29001·8	..	29117
Ladnia	1849	235	108·861	30171	28998·6	..	29144
Harpur	1849	219	111·523	30221	29026·1	..	29146
Minai	1850	228	113·761	30282	28990·4	..	29160
Suberkum	1881	11641	87·636	29576	..	29141	..
Do.	1883	11641	87·636	29572	..	29137	..
Tiger Hill	1880	8507	107·952	29860	..	29140	..
Sandakphu	1883	11929	89·666	29620	..	29142	..
Phallut	1902	11816	85·553	29589	..	29151	..
Senchal	1902	8599	108·703	29941	..	29134	..
Mean	..	..	..	..	29002	29141	29141
Range of variation in values*	..	..	..	794	Misleading.†	17	43

The 5th column gives the values of height obtained from observation, if no correction for refraction be applied. It will be noticed that all the values of height in this column derived from observations taken at low-lying stations exceed 30,000 feet, whereas those derived from observations taken at high altitudes are less than 30,000 feet.

The reason of this difference is that refraction tends to elevate a peak to a greater extent when the observation is made through the thick atmosphere of the

* The range of variation is the difference between the largest and smallest values of height in the column above; it is the maximum discordance obtained, and as such it furnishes evidence as to the correctness of the refraction coefficient adopted.

† The extent of the range of variation affords no useful information unless the same value for refraction has been employed throughout. By using selected values of refraction we can make all values of height identical and have no range of variation at all.

plains than when the line of sight passes only through the rarefied air of hill stations. It will be noticed that when no correction for refraction is applied, the largest of the values in the 5th column differs from the smallest by 794 feet, but that the application of corrections reduces the discrepancies materially.

The height 29,141 is still probably too small, as it has yet to be corrected for the effects of deviations of gravity. Though it is a more reliable result than 29,002, the latter value is still to be retained in maps and publications of the Survey. We cannot claim to have solved the problems of refraction, nor to have eliminated all uncertainties: our knowledge of the deflections of gravity is still but superficial, and although we may endeavour continually to improve our heights, it would be a mistaken policy to introduce new values at every step of the investigation. Values of heights, as has been explained in a previous section, furnish means of identification and are not to be altered frequently or without good reason. We have discussed the height of Mount Everest to show the degree of uncertainty attaching to it, but we do not propose to substitute 29,141 for the long adopted and well-known value 29,002. (*Survey of India, Professional Paper No. 9, 1905*).

Deduction of the height of Kānchenjunga.—It is probable that the accepted height of Kānchenjunga is, like that of Mount Everest, too small: the following table shows how the height has been deduced:—

TABLE X.—Height of Kānchenjunga.

Station of observation.	Year of observation.	Height of station of observation.	Distance from Kānchenjunga.	Values of height, if no correction for refraction be applied.	Resulting height as determined by Waugh with co-efficients of refraction varying from 0·07 to 0·09 from stations in the plains.	Resulting height from computations in 1905 with coefficient of refraction 0·05 from stations in the hills.	Resulting height with assumed coefficient of refraction 0·0645 from stations in the plains.
		Feet.	Miles.	Feet.	Feet.	Feet.	Feet.
Dumdāngi	1847	307	84·951	28856	28137·8	..	28224
Thakurganj	1847	264	88·491	28948	28138·3	..	28266
Bandarjūla	1847	238	92·560	29060	28128·6	..	28312
Minai	1850	228	115·174	29494	28162·5	..	28346
Baisi	1850	234	115·631	29483	28152·1	..	28322
Harpur	1849	219	124·694	29651	28133·7	..	28297
Senchal	1847	8599	50·158	28401	28138·8	28231	..
Birch Hill	1847	6874	44·907	28379	28152·3	28239	..
Tonglu	1847	10073	46·369	28370	28169·6	28220	..
Observatory Hill . . .	1884	7162	45·720	28353	..	28212	..
Mean	..	..	..	..	28146	28226	28295
Range of variation in values*	..	..	..	1298	Misleading. †	14	122

* The range of variation is the difference between the largest and smallest values of height in the column above; it is the maximum discordance obtained and as such it furnishes evidence as to the correctness of the refraction coefficient adopted.

† The extent of the range of variation affords no useful information unless the same value for refraction has been employed throughout. By using selected values of refraction we can make all values of height identical and have no range of variation at all.

If we examine the results of the 5th column, which have not been corrected for refraction, we find that all the heights derived from observations at low-lying stations exceed 28,800 feet, and all those derived from observations made at high altitudes are below 28,410. The heavy atmosphere of the plains had greater refracting effects than the rarefied air of the hills and raised the peak to a greater extent.

If no correction for refraction be applied, the values of height vary from 28,353 to 29,651, a discrepancy of 1298 feet: the 7th and 8th columns show how this discrepancy can be reduced by corrections for refraction.

Deduction of the height of Dhaulāgiri.—The following table shows how the height of Dhaulāgiri was obtained: no observations have been taken to it from stations in the hills:—

TABLE XI.—Height of Dhaulāgiri.

Station of observation.	Year of observation.	Height of station of observation.	Distance from Dhaulāgiri.	Values of height, if no correction for refraction be applied.	Resulting height as determined by Waugh with coefficients of refraction varying from 0·07 to 0·09.	Resulting height with assumed coefficient of refraction 0·0645.
		Feet.	Miles.	Feet.	Feet.	Feet.
Morairi	1848	334	105·975	27974	26791·0	27002
Banarsia	1849	329	95·625	27928	26773·8	27128
Saunbarsa	1849	315	104·043	28093	26830·8	27151
Purena	1849	299	105·800	28011	26813·1	27044
Ghaus	1849	327	95·812	27852	26775·5	27052
Tulsipur	1848	376	104·461	27930	26824·8	26988
Anārkali	1848	434	137·340	28640	26756·6	27002
Mean	..	..	..	..	26795	27052
Range of variation in values *	..	..	..	788	Misleading.†	163

The height 26,795 is too low: the reductions made on account of refraction were too great.

The observations in the North-west Himālaya of the great peaks of K², Nanga Parbat, etc., were taken not from low dusty hazy plains as those of the Nepālese peaks were, but from high stations, and the rays passed through a rarefied atmosphere.

* The range of variation is the difference between the largest and smallest values of height in the column above; it is the maximum discordance obtained and as such it furnishes evidence as to the correctness of the refraction coefficient adopted.

† The extent of the range of variation affords no useful information unless the same value for refraction has been employed throughout. By using selected values of refraction we can make all values of height identical and have no range of variation at all.

Deduction of the height of K².—The height of K² was deduced by Colonel Montgomerie as follows :—

TABLE XII.—Height of K².

Station of observation.	Year of observation.	Height of station of observation.	Distance from K².	Values of height, if no correction for refraction be applied.	Resulting height as determined by Montgomerie with co-efficients of refraction varying from 0·04 to 0·05.
		Feet.	Miles.	Feet.	Feet.
Shangruti	1859	17531	78·9	28640	28246·6
Biāchūthūsa	1859	16746	99·0	28846	28218·7
Marshāla	1858	16906	58·6	28472	28240·0
Kāstor	1858	15983	66·0	28560	28261·4
Thurigo	1858	17246	61·8	28515	28254·1
Harāmukh	1856	16001	136·5	29300	28293·9
Kanūri-Nār	1857	15437	114·3	28920	28218·4
Bārwāi	1857	16304	88·0	28666	28258·5
Thalanka	1857	16830	74·7	28613	28322·7
Mean	..	..	..	..	28253
Range of variation in values *	..	..	..	828	104

Deduction of the height of Nanga Parbat.—The following table shows the height of Nanga Parbat as deduced from the observations using different refraction coefficients :—

TABLE XIII.—Height of Nanga Parbat.

Station of observation.	Year of observation.	Height of station of observation.	Distance from Nanga Parbat.	HEIGHT WITH REFRACTION COEFFICIENTS OF										
				0·00	0·01	0·02	0·03	0·04	0·05	0·06	0·07	0·08	0·09	0·10
		Feet.	Miles.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
Ahartātopa	1855	13029	133·744	27885	27646	27407	27168	26929	26689	26449	26210	25970	25734	25494
Pahārgarh	1855	11356	118·751	27680	27492	27304	27116	26923	26739	26551	26362	26174	25988	25800
Gogipatri	1855	7752	95·055	27332	27211	27090	26969	26848	26726	26604	26485	26363	26243	26124
Harāmukh	1856	16001	59·275	26882	26835	26788	26741	26694	26647	26599	26552	26505	26460	26413
Kāzi Nāg	1856	12111	73·559	27028	26956	26884	26812	26740	26669	26595	26524	26452	26380	26307
Poshkar	1856	8323	83·491	27219	27125	27031	26937	26843	26749	26654	26562	26468	20376	26282
Ismāīl-di-dori	1856	12630	63·805	26947	26892	26837	26782	26727	26671	26617	26563	26508	26454	26400
Safāpur	1856	10296	66·339	26917	26858	26799	26740	26681	26624	26564	26506	26447	26387	26329
Hānt	1856	13479	43·167	26771	26746	26721	26696	26671	26646	26621	26596	26572	26546	26522
Menganwār	1856	8715	56·510	26854	26811	26768	26725	26682	26638	26596	26553	26510	26467	26425
Marināg	1856	11814	46·342	26780	26751	26722	26693	26664	26636	26606	26579	26549	26520	26492
Mean	..	..	..	27118	27029	26941	26853	26764	26676	26587	26499	26411	26323	26235
Range of variation in values.*	..	..	..	1114	900	686	475	265	125	205	386	602	812	1028

* The range of variation is the difference between the largest and smallest values of height in the column above ; it is the maximum discordance obtained and as such it furnishes evidence as to the correctness of the refraction coefficient adopted.

It will be noticed that when a coefficient of 0·10 is used, the height of Nanga Parbat as determined from different places varies between 25,494 and 26,522, a range of 1,028 feet.

This great variation shows that the coefficient of 0·10 is inapplicable: with a coefficient of 0·09 the height varies from 25,734 to 26,546, a range of 812 feet. The range of variation decreases, until with a coefficient of 0·05 all the values of height fall between 26,624 and 26,749, a range of 125 feet. If we decrease the coefficient still further to 0·04, the variations again begin to increase, and the range extends to 265 feet, from 26,664 to 26,929 : if the coefficient be decreased to 0·00 the range of variation becomes 1,114 feet.

The actual height adopted by Montgomerie for Nanga Parbat was 26,620, and we are unable to improve upon his value : it is produced if a general coefficient of 0·057 be accepted for refraction.

The rise of the Himālaya.—Is the great Himālaya range still rising? This is a question often asked but which no one has been able to answer. The observations of peaks made between 1850 and 1860 were not sufficiently prolonged at any one station to enable us to rely with certainty on the values of height then obtained. When the absolute height of a peak is being measured, stations of observation have to be multiplied in order to cancel the effects of refraction and gravity, but when a slow variation in height is being determined, it is better to carry out long series of observations from one station only. In the latter case differences are being sought, not absolute heights, and all that is necessary is to repeat observations from the same station, on the same days of the year, and under the same conditions. In 1905 a series of observations was commenced from the trigonometrical station of Nojli, and it is proposed to observe the heights of several peaks for some years and at different seasons in each year. If a reliable series of results be once obtained, a similar set of observations can be repeated at a subsequent date and any actual change of height that has occurred in the interim may be discovered.

The Siwālik range was elevated at a more recent date than the Himālaya, and is the most likely of all the ranges to be rising still : a bench-mark has been placed on the crest-line south of Dehra Dūn, and its height has been determined by spirit-levelling : if the bench-mark is preserved, future changes in altitude should be discoverable.

Slow changes in the level of land, unaccompanied by sudden movements, have been observed to occur along many coasts. At great distances from the sea such changes would take place without being noticed : without the aid of the sea as a datum we do not observe slow gradual movements, and a continuous rise of a foot a year might go on for centuries without attracting the attention of man. If an earthquake occurs and a tract of land suddenly subsides along a line of fracture in the crust, the result is apparent and measurable, but if the elevation

of a large area takes place in all directions gradually and without fracture of the crust or any marked upheaval it may be considerable and yet escape observation. In the Dharmsāla earthquake of 1905 an immense region may have been elevated or depressed through many feet, but if the change were nowhere sudden we should not without refined trigonometrical observations become aware of its occurrence.

(ii) THE PROBLEM AS VIEWED IN 1931.

(*a*) *Atmospheric Refraction.*

Since 1907 a great advance has occurred in our knowledge of atmospheric refraction, which has been due to the investigations of Dr. de Graaff Hunter (*Professional Paper No. 14*). Hunter has shown that the refraction of a ray depends upon the heights above sea-level of the two stations at the ends of the ray, and upon the temperature and pressure at the station of observation. Instead, therefore, of assuming (as we formerly did) a somewhat arbitrary coefficient of 0·05 at hill-stations and of 0·0645 in the plains, the Survey of India now employs a value which is definitely dependent upon height, temperature and pressure.

The value is obtained from a table and its use results in a considerable increase of accuracy,* provided we always observe as heretofore at the time of minimum refraction. The atmospheric pressure and the temperature lapse rate (or rate of change of temperature with height) are the factors which principally affect the coefficient of refraction. The former can be measured, or estimated with very fair accuracy, whereas the lapse rate cannot, and the latter is the principal source of uncertainty. The table has been calculated on the assumption that the lapse rate is 3°F. per 1000 feet, a value which observation has shown to be fairly typical except in close proximity to the ground.

During the last century many observers, including Sir Andrew Waugh, and many computers, including Radhānāth Sikhdār, devoted their time and thought to the study of refraction. They were well aware of its wild behaviour, of its changeableness, its inconstancy, its distortions and its multiplication of images, but they could find no method underlying its caprices. To all who have been interested in the scientific history of the Survey and who have been aware of the difficulties which it has encountered in obtaining corrections for refraction, it will be a source of satisfaction to feel that the solution of the problem should have at last been discovered, not by investigators in Europe or America, but by researches at Dehra Dūn.

Some knowledge has also been obtained by Hunter's investigations of the variation of the refraction between morning, afternoon and evening. Our knowledge of this variation is not sufficient to justify the deliberate taking of observations in the morning or late evening, but it enables us to utilise old observations which have been made at these hours.

* Auxiliary Tables, 5th Edition, Part III, Table 5 Sur.

By making use of this increased knowledge of refraction, and by applying corrections for the deflections of the plumb-line, Dr. de Graaff Hunter has obtained values of 29,149, 28,287, and 27,016 for the heights of Mount Everest, Kānchenjunga, and Dhaulāgiri respectively.

(b) *The Replacement of the Spheroid by the Geoid.*

The following extract is from a paper by Dr. Hunter, dated 1931 :—

The most difficult question of all still remains to be considered. Above what datum are these heights measured ? Are they measured above Everest's spheroid, to the geometrical surface of which all Indian latitudes and longitudes are referred, or are they measured above the geoid, the slightly irregular surface which would be assumed by the surface of the sea, if the sea could be extended into the middle of the continents by small frictionless canals ? The answer to this question is that as they stand the figures refer to neither of these surfaces. The heights given in Tables IX, X, and XI are with reference to various spheroidal surfaces, each with curvature equal to that of Everest's spheroid, but placed so as to be tangent to the geoid at each station of observation. Strictly speaking the result given in each line of these tables is referred to a different datum.

Two datum surfaces have been mentioned above, the geoid and the spheroid. Which of these ought logically to be used ? The answer is that either may be used, provided it is used consistently, with a slight preference for geoidal heights since they are the measure of the amount of effort required to reach the top of a hill, and of the fall available for power or irrigation. In practice the most accurate way of measuring heights, so far as instrumental errors are concerned, is spirit-levelling, and when possible all triangulated heights are adjusted to spirit-levelled heights. Now spirit-levelled heights are geoidal heights, for the bubble in the level is affected by the same influences as the sea-level in the hypothetical canals by which the geoid is defined. We are then forced to the conclusion that the geoid must be accepted as the datum of height.

The heights obtained by ordinary triangulation, with fairly short rays, used without correction for deflection of the plumb-line, are also a fairly close approximation to geoidal heights. But when peaks are fixed by rays 100 miles long, passing over mountainous country in which great deflections occur, the height obtained without correcting for deflection is by no means an accurate geoidal height. Under these circumstances it becomes necessary to obtain a spheroidal height by correction for the deflection, and then to try to estimate the separation between geoid and spheroid under the peak.

The following are probably correct geoidal heights within 50 feet.

Mount Everest	29,050
Kānchenjunga	28,200
Dhaulāgiri	26,925

We can summarise the height of these three mountains as follows :—

—	Above an Everest spheroid which coincides with the geoid south of Nepāl.	Above the geoid.
Everest	29149 ± 5	29050 ± 15
Kānchenjunga	28287 ± 2	28200 ± 15
Dhaulāgiri	27016 ± 5	26925 ± 15

CHAPTER 6.

THE GEOLOGY OF THE GREAT PEAKS.

In dealing with the great peaks the geologist is at no small disadvantage as compared with the surveyor, whose instruments enable him to work from a distance and to fix with accuracy the position and height of the object of his observation. The geologist, on the other hand, must toil arduously up the mountain sides, examining at close quarters such outcrops of rocks as he can find clear of snow, and, where further progress is barred, must depend for his information on fallen fragments, splintered from the cliffs above and brought down by avalanches and glaciers to form moraines and talus heaps. Thus the composition of the highest peaks is rarely known in any detail, but the general character of the rocks can be ascertained, with a fair approximation to certainty, from observation of the material on their flanks, and from a distant view of the weathering characters and apparent structure of the peaks themselves: it has thus been found that almost all those of 25,000 feet or more in height are composed of granite, gneiss, and associated crystalline rocks.

Of the granite there are at least two varieties, a foliated rock composed essentially of quartz, felspar, and biotite (black mica), and a younger non-foliated form containing, in addition to quartz and felspar, white mica (muscovite), black tourmaline, beryl, and various accessory minerals. The former variety was long regarded as a sedimentary rock which had been converted by heat and pressure into gneiss, but its truly intrusive nature was recognised by the late Lieutenant-General C. A. McMahon, who proved conclusively that the great central gneissose rock of the Himālaya was in reality a granite crushed and foliated by pressure. [*Records, Geological Survey of India,* Vol. XV (1882), p. 44, Vol. XVI (1883), p. 129, and *Geological Magazine,* Dec. III, Volume 4 (1887), p. 215]. This rock is frequently pierced by veins of the second or non-foliated variety, and where these run parallel to the foliation planes, they lend to the series a deceptive appearance of bedding and cause it, when seen from a distance, to be mistaken for a mass of stratified deposits. This is a common characteristic of the higher peaks and may be noticed in many of the granitic masses of the great Himālayan range.

Although our experience leads us to assume that all the highest peaks are composed largely of granite, many more observations must be made before this can be positively asserted to be the case.

Thus Chomo Lhāri (23,997 feet) is composed of foliated (gneissose) granite penetrated by veins of the non-foliated variety, and flanked by the altered representatives of slates and limestones metamorphosed by the granite which has been forced up through them from below. Further to the west, the Kānchenjunga group is largely formed of gneissic granite, flanked by metamorphic rocks

certainly in part derived from pre-existing sediments, but recrystallised by heat and pressure. The double peaks of the Jonsong La, for instance, are part of an inverted outlier of Mesozoic limestones, and the long range further north is composed of the same limestones, uninverted, but overthrust upon granite. [G. O. Dyhrenfurth, "Himalaya," Berlin (1931)].

The Everest group is a pile of altered sedimentary rocks, originally shales and limestones, converted into banded hornfels, finely foliated calc-schists and crystalline limestones, traversed by veins of white muscovite-tourmaline granite. [A. M. Heron, *Records, Geological Survey of India,* Vol. LIV, pt. 2, pp. 233-234, 1922]. These metamorphic rocks dip northward and are believed to pass into, or beneath, the highly folded Jurassic Spiti shales of the Tibetan plateau. Their age may be supposed to be Triassic or Jurassic. Downwards they pass into the banded Himālayan biotite-gneiss, which is intimately penetrated with sills and dykes of the muscovite-tourmaline granite. The gneiss is perhaps intrusive in these metamorphics, but whether it is wholly an igneous rock, or is a composite-gneiss formed by the injection and rolling out of granite veins along the foliation of mica-schists—highly altered, and possibly very ancient, sedimentaries—is as yet uncertain.

The conspicuous broad light brown band of rock, extending along into the base of the final pyramid, from the prominent shoulder, 27,390 feet, north-east of the main peak of Mount Everest, is not however, a sill of granite, as was stated in the account quoted above, but is really calcareous sandstone. [N. E. Odell, *Geographical Journal,* LXVI, pp. 289-315 (1925)]. The final pyramid is composed of dark calc-schist, very compact, dipping northwards at 30°.

Owing to the exclusion of British travellers from Nepāl, we know little or nothing of the geological characters of the peaks in Nepāl.

To the west of Nepāl we are on surer ground, since both Kumaun and Garhwāl have been geologically surveyed. Here again the high peaks, such as Nanda Devi, the Kedārnāth group and Kāmet [C. L. Griesbach, *Memoirs, Geological Survey of India,* Vol. XXIII, (1891), pp. 43, 90, 194], are all composed of granite and gneiss with gneiss and schist on their flanks, while granite is also probably the prevailing rock on Muztāgh Ata and the other high peaks of the Kāshgar range.

Nanga Parbat or Diamir is composed almost entirely of finely schistose, streaky biotite-gneiss with interbedded marbles, graphite-schists, etc., well-stratified, and with a persistent dip to the north-west. These are traversed by thick dolerite sills, now converted into massive amphibolite and hornblende-schist. D. N. Wadia ["Geology of Nanga Parbat, Mount Diamir," *Records, Geological Survey of India,* Vol. LXVI, pt. 2 (1932)] has no doubt that these gneisses are metamorphic products of the pre-Cambrian Salkhala series, which constitutes the surrounding region. Through this para-gneiss complex are intruded sheets and dykes of later gneissic granite and of this the summit of the mountain is largely composed.

Recent work by the Italian and other expeditions in the Karakorum show that sedimentary rocks enter into the architecture of the high peaks of that region to a greater extent than in the cases already cited. The Crystal * and Gasherbrum groups are composed of grey and black limestones with fossils which show them to be Permo-Carboniferous in age [Ardito Desio, *Geographical Journal.* LXXV, No. 5, pp. 402-411, (1930)].while Broad Peak has the same limestones on its eastern side, with, on the north, shales, gneiss, granite and epidiorite with serpentine.

The Golden Throne † region is composed of many-coloured limestones ; the peaks of the Skamri range comprise a great sequence of white and grey crystalline limestones, which form the right side of the Drenmang valley and the left side of the Nobundi Sobundi valley.

The north slope of the southern divide of the Baltoro glacier (the Masherbrum-Chogolisa chain) is biotite-gneiss, with dykes of granite, as is the Muztāgh Tower.

The commanding pyramid of K^2 is composed of well-stratified gneiss, with granite dykes cutting through it, with its summit of clear gneiss.

The general sequence in the Karakorum, as described by Ardito Desio, is somewhat similar to that of the Everest region. The basis is light-grey gneiss, occasionally porphyritic, crossed in all directions by great granite dykes ; in higher levels the content of biotite increases, giving the gneiss a more pronounced schistosity and a darker colour. Next to these occur very thick shales, passing upwards into limestones interbedded with shales, schists, epidiorites and serpentines. Where metamorphism has been less pronounced, the sedimentaries yield fossils which show them to range in age from the *Fenestella* shales (Middle Carboniferous) to the Trias.

This correspondence between the great elevation and the geological structure of the high peaks appears to be too constant to be attributable to mere coincidence, and we are forced to the conclusion that their exceptional height is due to the presence of granite. This may be explained on two separate grounds, either (*a*) that the superior power of the granite to resist the atmospheric forces tending to their degradation has caused them to stand as isolated masses above surrounding areas of more easily eroded rocks, or (*b*) that they are areas of special elevation.

If now we examine the relationships of the peaks to one another, we find that along certain definite lines the intervening areas are also frequently composed of the same granite as the peaks themselves, and if we follow these definite lines we further find that they constitute the axes of the great mountain ranges. Thus the great peaks lie on more or less continuous and elevated zones composed of granite and crystalline rocks, and since the lower portions of the zones are of the same composition as the peaks themselves, it is difficult to regard the latter merely as relics of a once continuous zone of uniform height, and it seems probable that

* Crystal group (19,400 ft.) in the Karakorum lies south-east of K^2 at the junction of the Baltoro and Godwin-Asuten glaciers.

† The Golden Throne (23,600 ft.) is at the head of the Baltoro glacier on its southern divide.

special elevating forces have been at work to raise certain parts of the zone above the general level of the whole; when once such elevation has been brought about, the disparity between the higher peaks and the intervening less elevated areas would undoubtedly be intensified by the destructive forces at work; the mantle of snow and ice, while slowly carrying on its own work of abrasion, will serve as a protection for the peaks against the disintegrating forces of the atmosphere, whilst the lower unprotected areas will be more rapidly eroded.

By the assumption that the higher peaks are due to special elevatory forces, it is not intended to imply that each peak is the result of an independent movement, for it has already been shown in a previous section of this paper that the peaks occur in well-marked clusters, any one of which may cover an area of many hundred square miles: when, therefore, during the development of the Himālaya as a mighty mountain range vast masses of granite welled up from below, forcing their way through and lifting up the pre-existing rocks above, it is probable that owing to dissimilarity of composition and structural weaknesses in certain portions of the earth's crust, movement was more intense at some points than at others, and that the granite was locally raised into more or less dome-like masses standing above the general level of the growing range: these masses were subsequently carved by the process of erosion into clusters of peaks. Whether the elevatory movement is still in progress it is not at present possible to say, but many phenomena observable throughout the Himālaya and Tibet lead us to infer that local elevation has until quite recently been operative, and the numerous earthquakes still occurring with such violence and frequency forcibly remind us that the Himālaya have by no means reached a period of even comparative rest.

APPENDIX 1.

A SYNOPSIS OF THE LINGUISTIC SURVEY OF INDIA.

The volumes of the Linguistic Survey of India by Sir George Grierson were published in 1927, and they are a monument of scientific research. The 723 different languages and dialects of India are divided into three families, the Indo-European, the Mongolian, and the Dravidian. This classification does not agree exactly with that adopted by ethnologists; the latter have classed Europeans and Indians together as Aryans, but in the Linguistic Survey the Indo-European family is divided into two sub-families, the Aryan and the European. The word Aryan has been frequently used in the past as equivalent to Indo-European, and English, Latin and German are sometimes called Aryan languages. Grierson protests against this misuse of the word Aryan, and he only applies it to the eastern branch of the Indo-European family; the English, Latin and German languages are other branches of the same family.

The Aryan sub-family has three divisions, the Iranian, the Indo-Aryan and the Dardic.

Iranian.—The Iranian languages consist of Persian, Pashtu (Afghānistān), Baluchi, and Kurdish, and also of some minor dialects spoken in Chitrāl and the Pāmirs.

Indo-Aryan.—The Indo-Aryan languages include Sanskrit, Panjabi, Sindhi, Marathi, Bengali, Hindi, Gujarāti, Assamese and others. This Sketch of Himālayan Geography and Geology is only concerned with those Indo-Aryan languages which are spoken in the mountainous regions separating India from Tibet, and which are classified by Grierson as the "Pahāri group". Eastern Pahāri is sometimes called Parbatiya, sometimes Gurkhāli, sometimes Khāskhura; it is not spoken outside Nepāl except by soldiers of the Gurkha regiments and the various Gurkha colonies in India. Eastern Pahāri is called Nepāli by Europeans, as though it were the principal language of Nepāl. In Nepāl the principal languages are not Indo-Aryan but Mongolian, the most important being Newāri. Eastern Pahāri is the language of the court in Nepāl, but it has borrowed words from the Tibeto-Burman languages and now presents a mixed character.

Central Pahāri includes the dialects known as Kumauni and Garhwāli; both are written in the Nāgri character.

Western Pahāri is the language spoken in the Himālayas between the Jumna and Kashmīr. It has numerous dialects differing considerably. They are closely related to the languages of Rājputāna and Gujarāt.

Dardic.—The only other Aryan languages in the Himālayas are those known as Dardic. Dardistān is the home of the Dardic languages; it includes Kashmīr, and Gilgit, the Indus and Swāt Kohistāns, Chitrāl and Kāfiristān.

The two principal Dardic languages are the Kashmīri and the Shina, and these are of geographic importance; Shina is the language of Gilgit and of a large area of mountain country between Baltistān and Kashmīr. In former times it extended into Western Tibet, where Francke found traces of it in the place-names, but it has now been superseded there by Tibetan dialects, and old Dard sites on the Indus are now occupied by Tibetans.

Grierson writes that Kashmīri is a mixed form of speech, and that its base is akin to Shina. and that many of its words are of Dardic origin. But Kashmīr has received many immigrants, and for centuries it has been a home of Sanskrit study. The learned Kashmīris themselves regard their language as truly Indian, but Sir George Grierson writes that "no philologist can "have any doubt that Kashmīri has a Dardic basis."

In Hunza-Gilgit there is an aboriginal language, Burushaski, still spoken; it was probably the language of the country 4000 years ago, before the invasion by the Aryan (Dardic) race.

THE MONGOLIAN LANGUAGES.

The Mongolian languages are divided into two sub-families, the Tibetan and the Tibeto-Burman.

The Tibetan languages.—In Tibet itself there are three dialects of Tibetan, namely Central Tibetan, Ladākhi and Balti. In the Himālayas there are four Himālayan dialects of Tibetan, namely Lhoke (also known as Drukpa) spoken in Bhutān, Da-njong-ka spoken in Sikkim, and Sharpa and Kagate spoken in Nepāl.

The Tibeto-Burman languages.—But there are an older set of Mongolian languages which crossed the Himālayas from the north even before Tibetan was established in Tibet (p. 12). These are the Tibeto-Burman languages; of these there is the Rong language of Sikkim, nicknamed Lepcha by the Nepālese. There are also the Newari, the Murmi, the Sunwar and the Magari dialects of Tibeto-Burman in Nepāl, and 26 other different dialects of Tibeto-Burman also spoken in Nepāl.

In addition to the dialects of Tibeto-Burman spoken in Nepāl, there are five such dialects in Kumaun spoken by races who live between the Pahāri-Indian races and the Tibetans.

There are also some Tibeto-Burman dialects spoken in the hills of Kanaur, of Kulu, of Kangra, of Chamba and of Lāhul.

Assam branch of Tibeto-Burman.—East of Bhutān the hills north of the Brahmaputra, extending beyond the extreme eastern corner of Assam are occupied by five tribes, the Akas, the Daflas, the Miris, the Abors and the Mishmis, each speaking their own dialect of Tibeto-Burman.

THE VOLUMES OF THE LINGUISTIC SURVEY WHICH REFER TO THE HIMĀLAYAS.

The Linguistic Survey of India has been published in 18 volumes, and these deal with the languages which are spoken in all parts of India and Burma. The volumes that deal with the languages of the Himālayas and Tibet are the following:

Indo-Aryan languages.

Vol. I, Part III. Comparative dictionary, Indo-Aryan languages.
Vol. VIII, Part II. Dardic, including Kashmīri.
Vol. IX, Part IV. Pahāri languages.
Vol. X. Iranian family of languages.

Mongolian languages.

Vol. I, Part II. Comparative Vocabulary.
Vol. III, Part I. Tibetan and Tibeto-Burman languages.

MGIPC—M—III-5-3—7-3-33—1,000.

CHART I

Peaks of the first magnitude

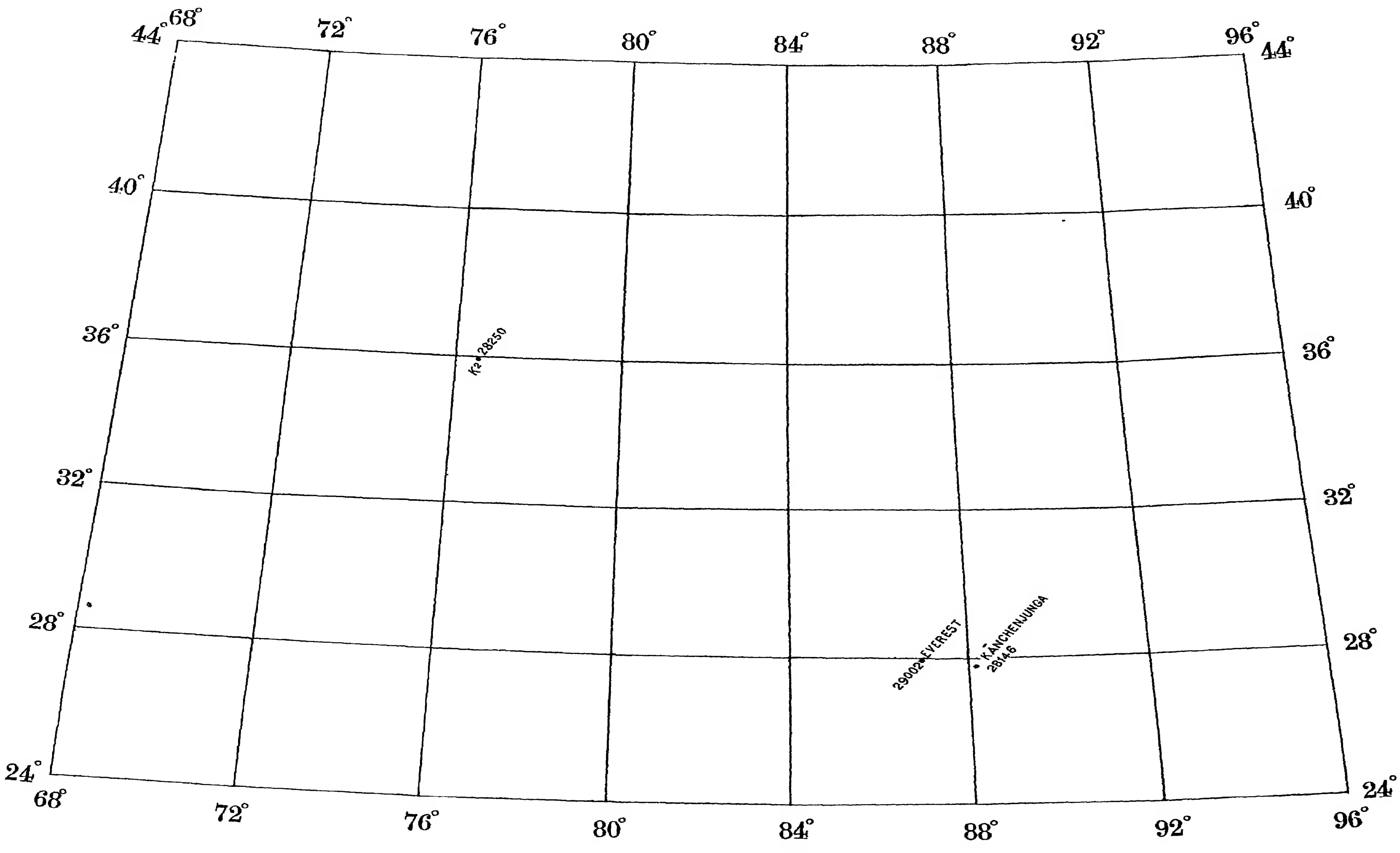


CHART II

Peaks of the second and first magnitude

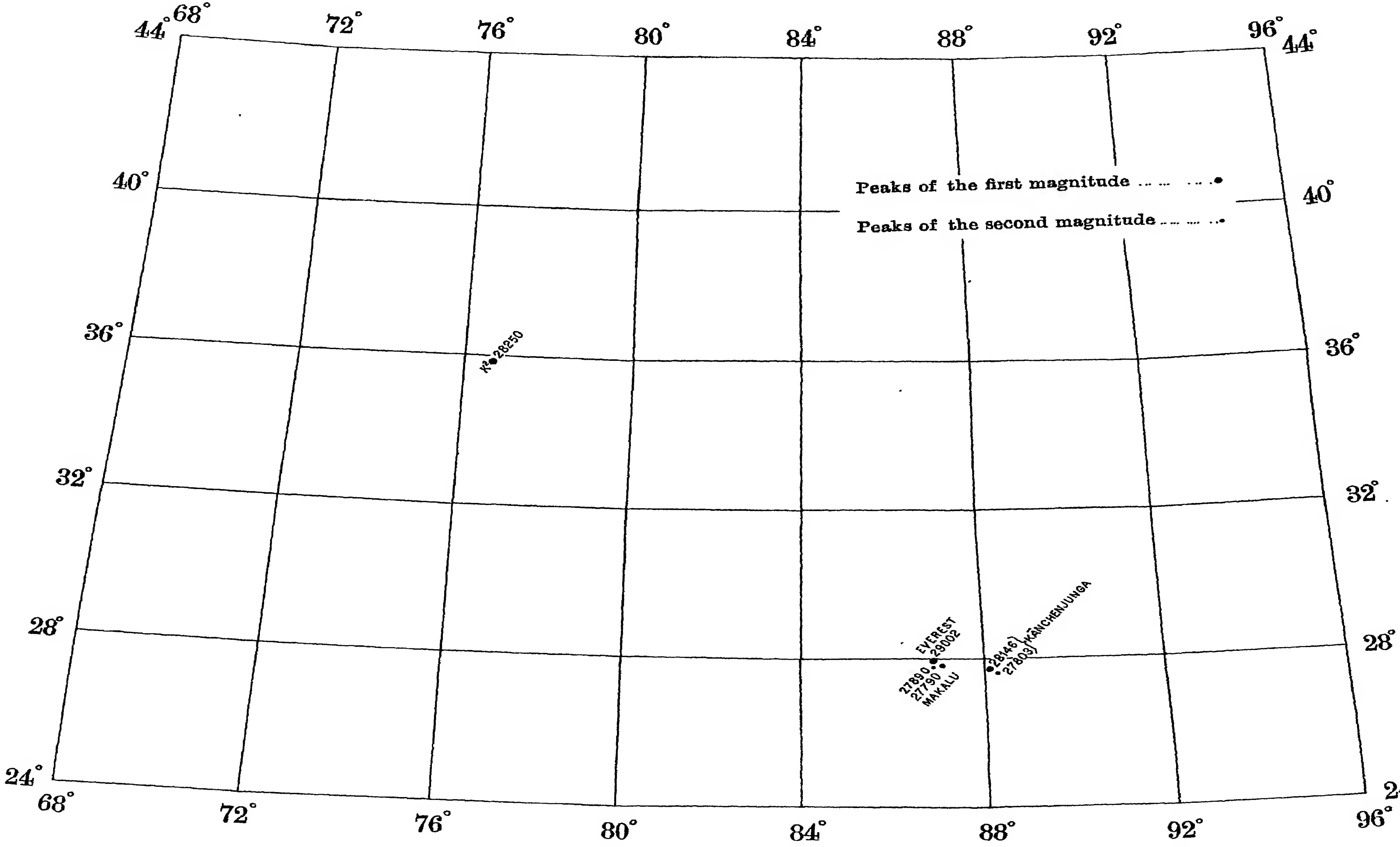


CHART III

Peaks of the third and higher magnitudes

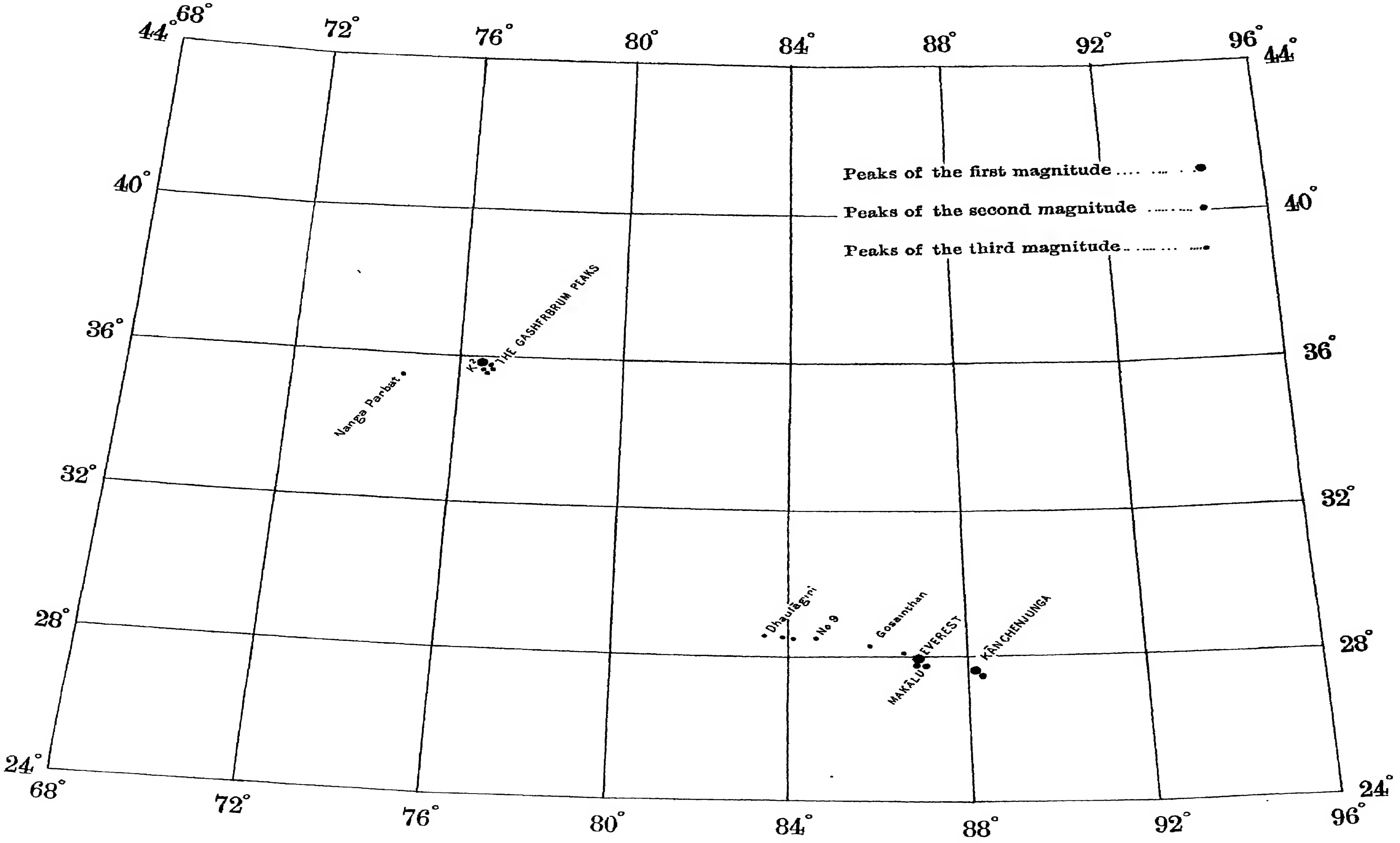


CHART IV

Peaks of the fourth and higher magnitudes

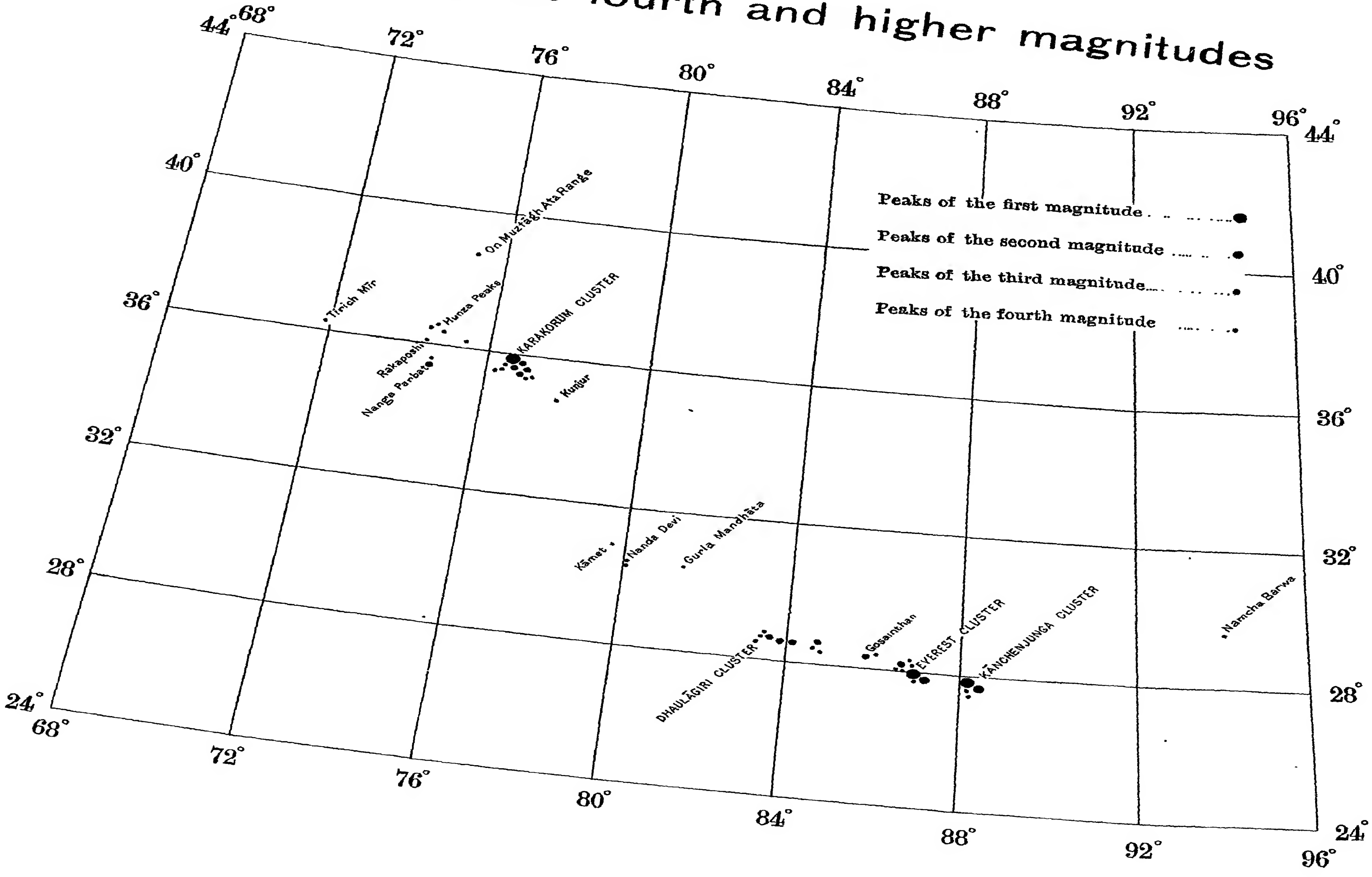


CHART V

PEAKS OF THE FIFTH AND HIGHER MAGNITUDES

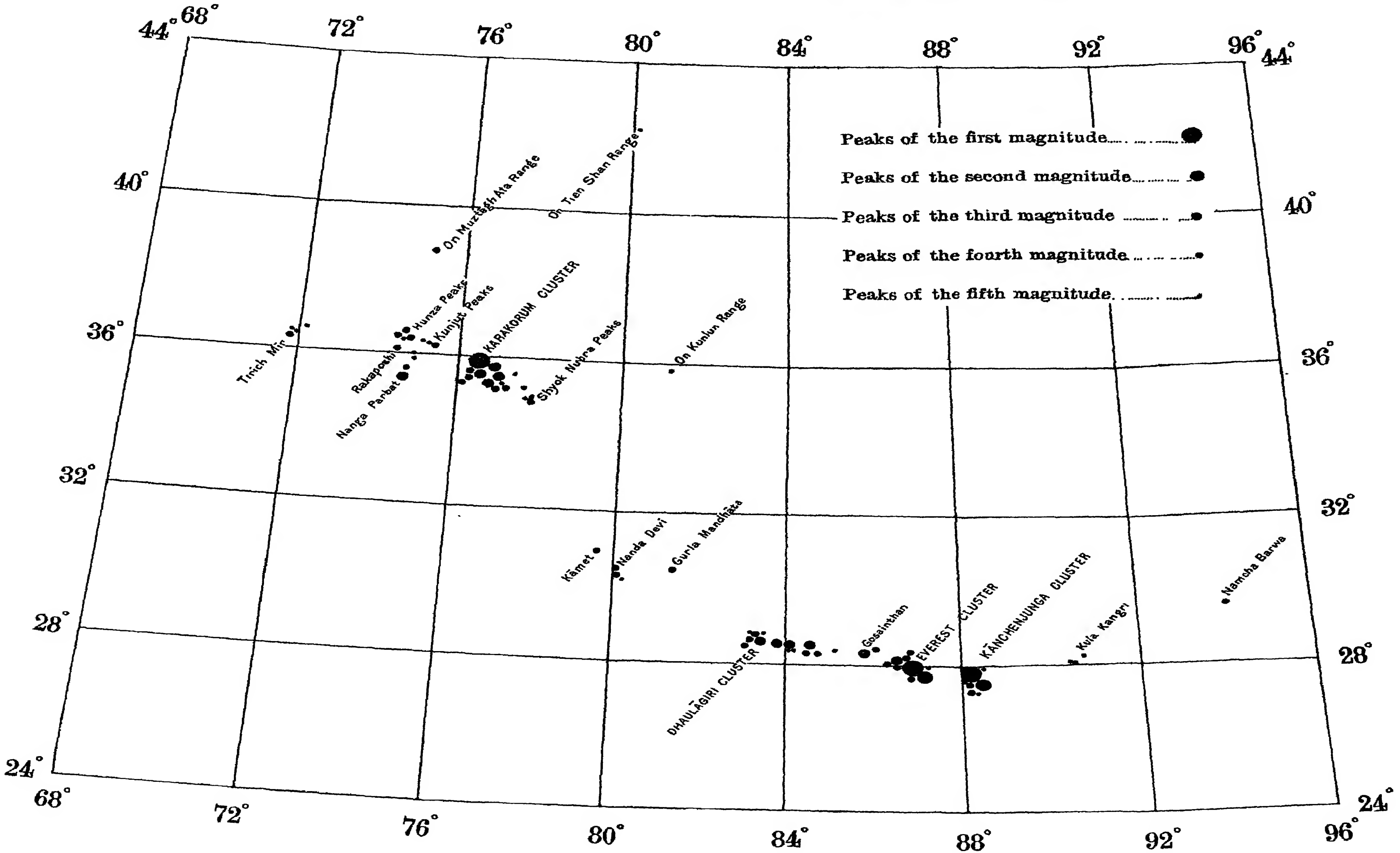
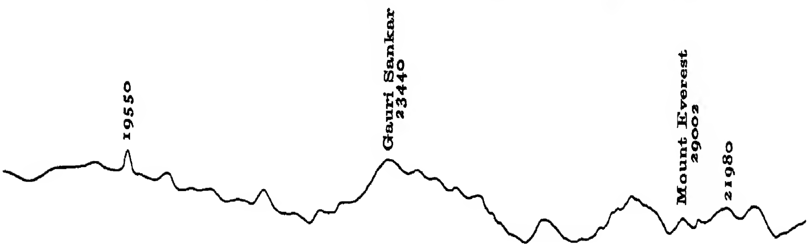
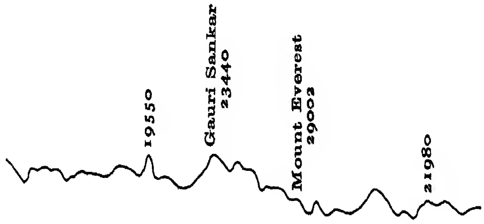


CHART VI

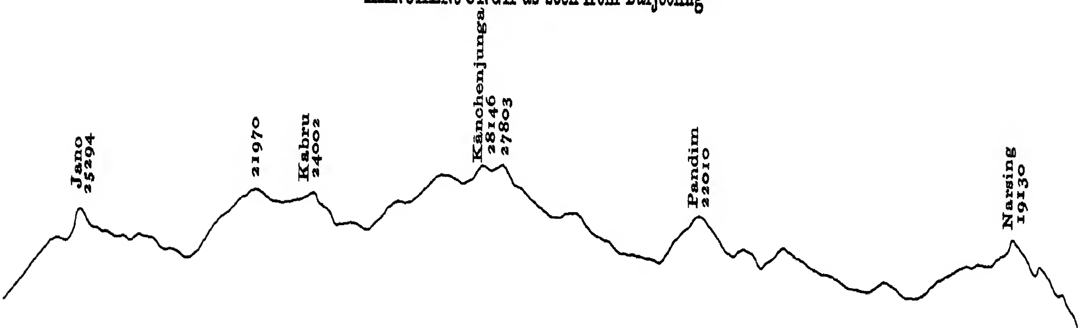
GAURI SANKAR and EVEREST as seen from Mahadeo Pokhara in Nepāl



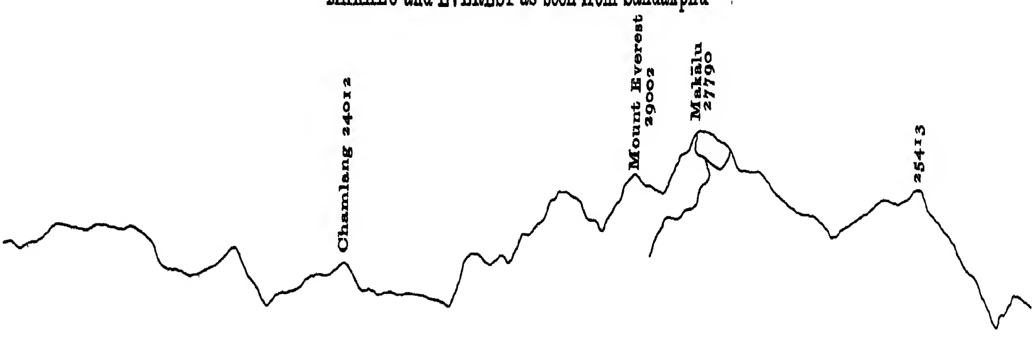
GAURI SANKAR and EVEREST as seen from Kaulia in Nepāl



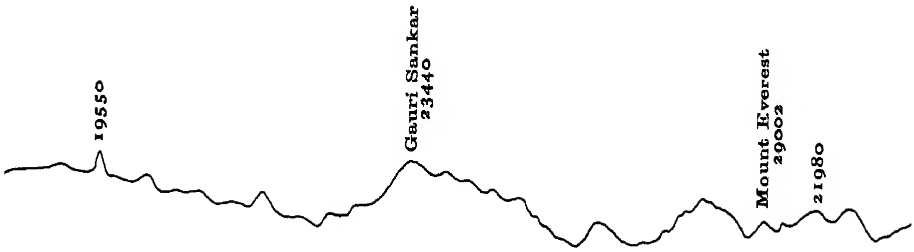
KĀNCHENJUNGA as seen from Darjeeling



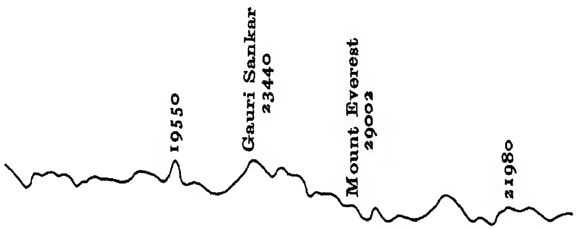
MAKĀLU and EVEREST as seen from Sandakphu



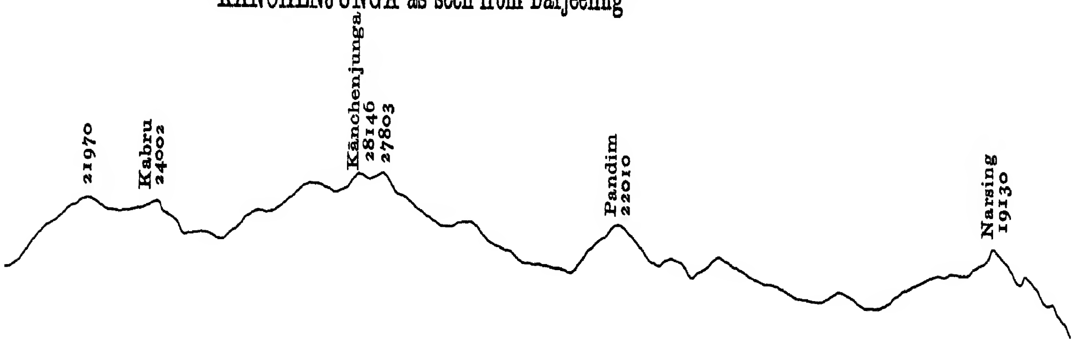
GAURI SANKAR and EVEREST as seen from Mahadeo Pokhara in Nepāl



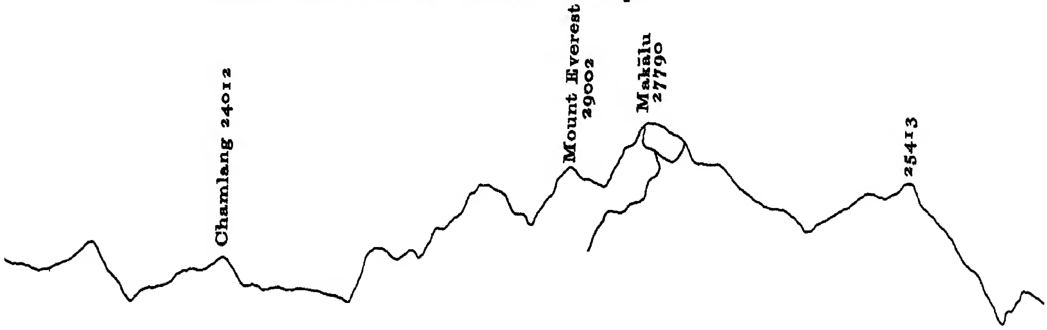
GAURI SANKAR and EVEREST as seen from Kaulia in Nepāl



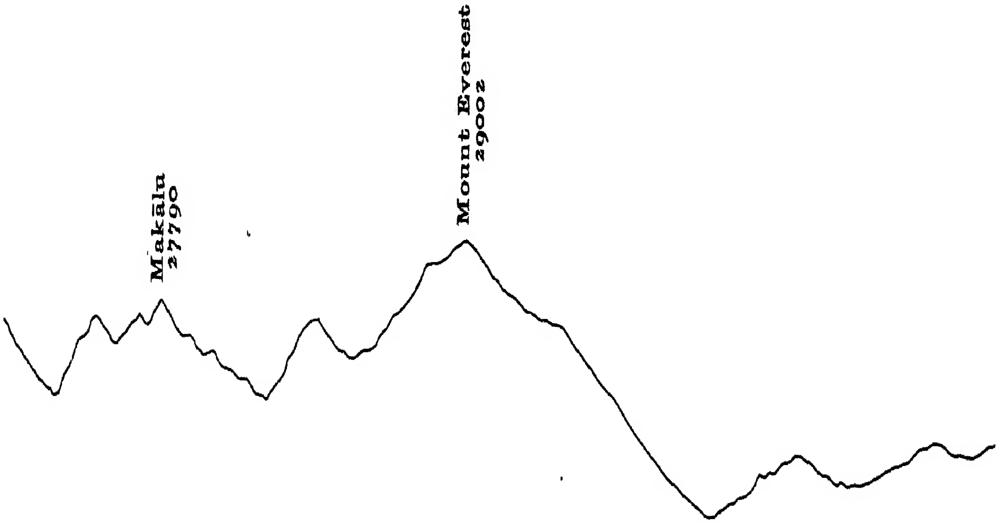
KĀNCHENJUNGA as seen from Darjeeling



MAKĀLU and EVEREST as seen from Sandakphu

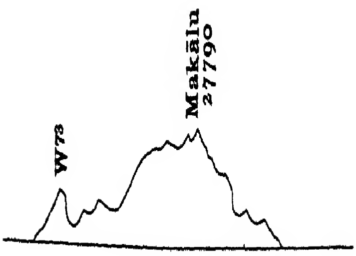


MAKĀLU and MOUNT EVEREST as seen from Kampa Dzong in Tibet



The azimuths and elevations of Mount Everest and Makālu were observed
from Kampa Dzong by Major Ryder in Season 1903-04

MAKĀLU and MOUNT EVEREST
as seen by Captain Wood from Pompa-zu-lung (height 18164 feet) in Tibet



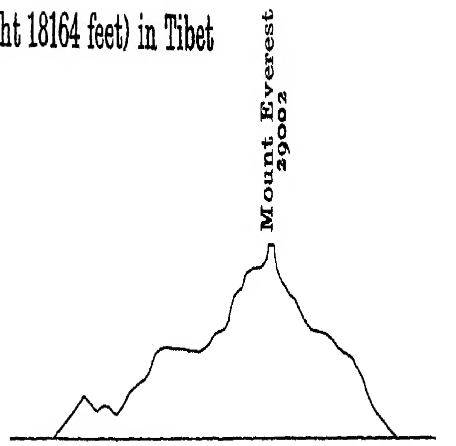


CHART VII

OUTLINE of the SNOWY RANGE as seen from Chīna (near Naini Tāl)

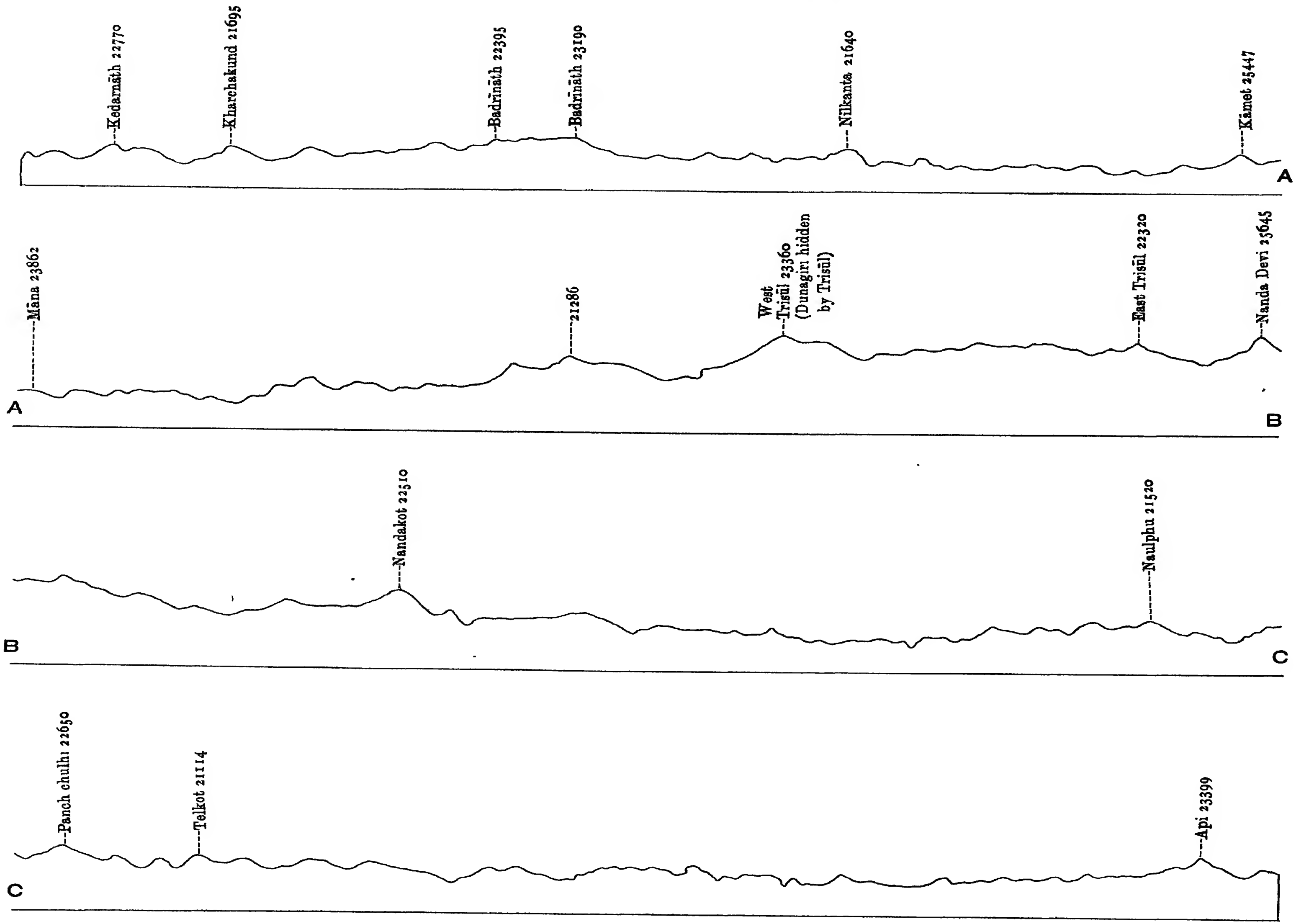
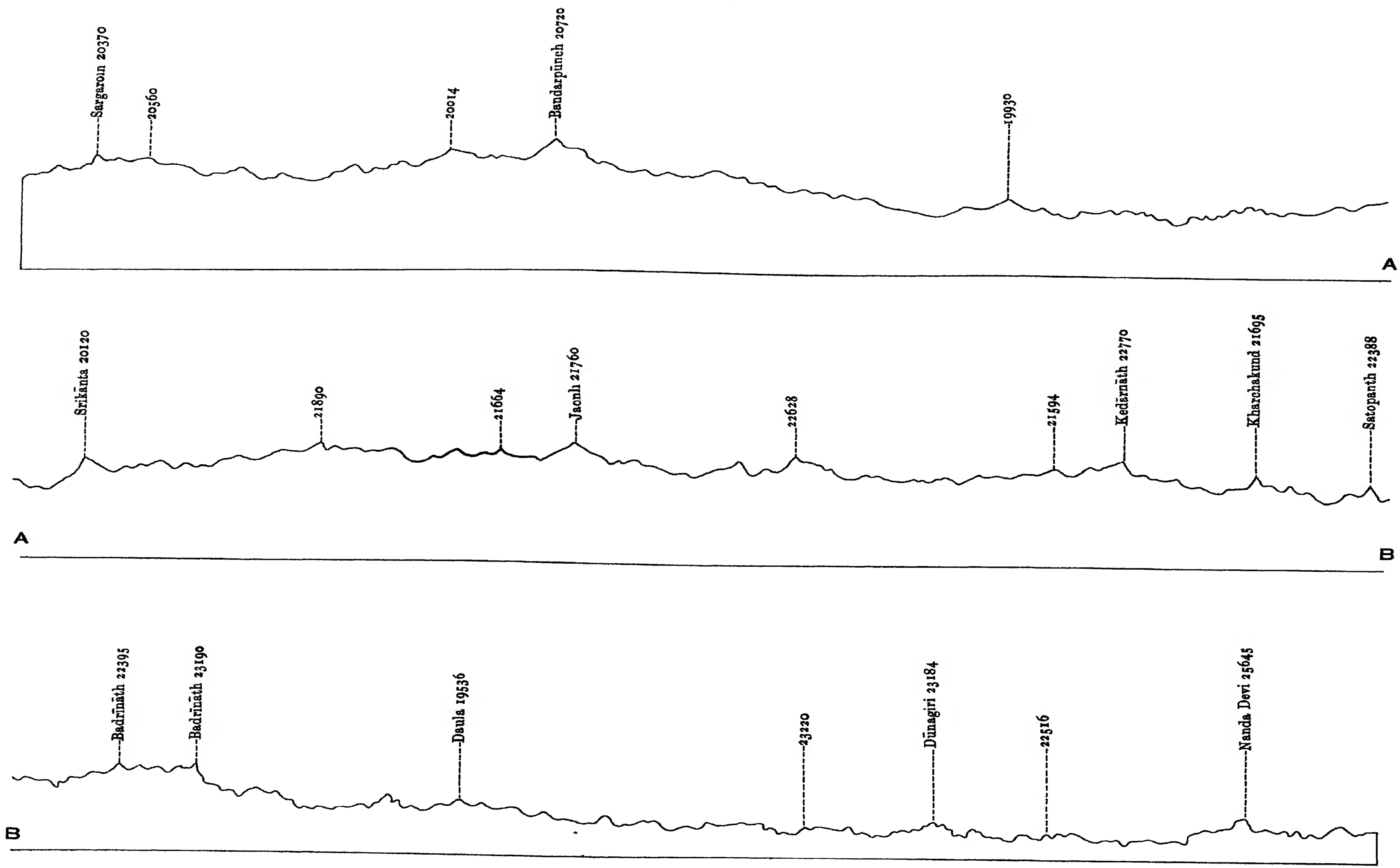


CHART VIII

OUTLINE of the SNOWY RANGE as seen from Landour



CHAPTER 7.

ON THE ORIGIN OF MOUNTAIN RANGES.

The floor of a former Tibetan sea has been raised and wrinkled.—The surface of Central Asia appears to consist of two primary elevations of the crust, separated by a trough-like depression; the southern elevation is the plateau of Tibet, the northern is the Tien Shan chain, the intervening depression is the Tārīm basin (see frontispiece, Part I). A second trough is to be seen south of the Tibet plateau, separating that plateau from the ancient Vindhya mountains; it is now filled with alluvium, and constitutes the plains of Northern India.

These two wide elevations of the crust and their complementary depressions form the basis of the mountains of Asia.

Until a comparatively recent date in the geological time-scale—the middle tertiary epoch—all the northern part of what is now the Himālaya, and probably the whole of Tibet were covered by a great sea,* in which deposition of sediment had continued for a vast period. At length, owing to forces the origin of which we can at present only conjecture, a period of crust-movement set in and the floor of the Tibetan sea began gradually to rise and to be thrown into a series of long parallel wavelike folds.

As the crests of the earth-waves rose from the waters of the sea, they were eroded by rain and weather, and the rising land became broken and irregular: drainage basins were carved out of its flanks and a river system, composed of "transverse" valleys, was gradually developed. As elevation continued, the troughs of the folds emerged and a series of "longitudinal" valleys was established at right angles to the transverse valleys and parallel to the longitudinal axes of the folds. From a combination of the concurrent processes of elevation and erosion, the existing mountain systems of the Himālaya and Tibet have been slowly evolved. As denudation has proceeded, deeper and deeper parts of the crust have been laid bare, but the forms of many folds can still be traced and the trends of their longitudinal axes followed for long distances. The folds, although analogous to waves, more nearly resemble the breakers on a beach than the swell of the open sea; the form of their surface is rarely that of a simple arch and trough; fold has been superimposed on fold, arches have been overturned until they are almost horizontal, and whole areas have been so distorted and crumpled, that the details of structure can only be unravelled

* This old sea of a previous geological age once covered much of Europe as well as Central Asia and has been named by Suess the "Tethys," *Natural Science*, Vol. II (1893), p. 183.

with difficulty. Where the stress has exceeded the breaking-strain of rock, the structure has been complicated by fracture; parts of the crust have in some cases subsided, and in others been moved horizontally. Nor are these the only causes of complexity, for along many of the planes of weakness and fracture molten material has been forced up from below, and has partly absorbed the original sediments.

The forces that raised the mountains.—Though the origin and nature of the forces which produced the Himālayan mountain system are not subjects which fall within the scope of this paper, it may not be out of place to allude briefly to the more important theories that have been put forward to explain the cause of folding.

The great series of parallel plications in Asia are supposed to have been caused by a horizontal thrust from the north: the sediments of the Eurasian sea were forced against the northern coast of the once continuous Indo-African continental mass which stood like a buttress in the path of the advancing earth-waves. The following hypotheses among others have been advanced to account for the origin of such a thrust:—

(*a*) Contraction of the earth.
(*b*) Disturbance of isostasy.
(*c*) Change in the rate of the earth's rotation.

(*a*) *Contraction of the earth.*—This hypothesis is based on the assumption that the earth as a whole is contracting in volume, owing to loss of heat or other causes, and that the rate of contraction of the inner nucleus is greater than that of the crust; the latter is thus left unsupported and becomes wrinkled, when adapting itself to its reduced core. Although this theory has met with wide acceptance, it has been adversely criticised by many authorities chiefly on the ground of the inadequacy of any known cause—whether it be gravitation or loss of heat—to produce contraction on a sufficiently large scale to account for the observed folding. *Vide* Rev. O. Fisher's *Physics of the Earth's Crust.*

The extent to which the surface of the earth has been contracted by folding appears to be considerable; it has, for instance, been calculated that the folds of the Alps represent a contraction of 74 miles, and it has been roughly estimated, that the original surface of Asia has been shortened by wrinkling between Siberia and India by at least 100 miles, and by possibly as much as 400. In the Sub-Himālaya C. S. Middlemiss found a contraction of 8 miles in 19. (*Memoirs, Geological Survey of India,* Vol. XXIV, Part 2, p. 77). Estimates of the contraction of the surface of the earth from the observation of folds are, however, of doubtful value. Even in areas of which the structure is known in greatest detail, the problem cannot be solved by simple measurements, for folds of strata have, in certain cases, been found to indicate stretching rather than contraction, and it is impossible to tell how far the one effect has balanced the other. In the Henry Mountains, G. K. Gilbert found that a bed of sandstone

had been stretched by 300 feet in a distance of three miles. (*Report on the Geology of the Henry Mts., U. S. Department of the Interior*, 2nd Edition, 1880, p. 75.)

(*b*) *Disturbance of isostasy.*—This hypothesis was put forward by Captain C. E. Dutton in the year 1889 (*Bull. Phil. Soc., Washington*, Vol. XI, 1892, pp. 51-64.). The term "isostasy" may be most suitably explained in Dutton's own words: "If the earth were composed of homogeneous matter its normal "figure of equilibrium without strain would be a true spheroid of revolution; "but if heterogeneous, if some parts were denser or lighter than others, its "normal figure would no longer be spheroidal. Where the lighter matter was "accumulated there would be a tendency to bulge, and where the denser matter "existed there would be a tendency to flatten or depress the surface. For this "condition of equilibrium of figure, to which gravitation tends to reduce a "planetary body, irrespective of whether it be homogeneous or not, I propose "the name *isostasy*. We may also use the corresponding adjective *isostatic*. "An isostatic earth, composed of homogeneous matter and without rotation, "would be truly spherical. But if the earth be not homogeneous, if some por-"tions near the surface be lighter than others, then the isostatic figure is no "longer a sphere or spheroid of revolution, but a deformed figure, bulged where "the matter is light and depressed where it is heavy."

The presence in mountain ranges of masses of shallow-water deposits, having a vertical thickness of many thousand feet, without break of continuity, proves that during vast periods of time deposition of sediment took place in seas of which the depth remained constant; this could only occur if the sea-floor continued to sink *pari passu* with the deposition of sediment. Observations have also shown that the adjacent land surfaces, from which the sedimentary material was being taken, were gradually rising, and Captain Dutton was led to conclude (*Op. Cit.*, p. 56) that "these subsidences of accumulated de-"posits and these progressive upward movements of eroded mountain plat-"forms are, in the main, results of gravitation restoring the isostasy, which "has been disturbed by denudation on the one hand and by sedimentation on "the other"; that is to say, the eroded portion becomes lighter and rises while the loaded area becomes heavier and sinks, isostatic equilibrium of the crust of the earth being analogous to hydrostatic equilibrium in a fluid. A cause has thus been suggested for the sinking of the sea-floor on the one hand and the rising of the land on the other; but in order to explain the folding of the deposits laid down, it is necessary to take a step further and assume, as Dutton has done, that as sediment accumulates, the lower layers, owing to the pressure of the overlying material, acquire a certain amount of plasticity, and that there is produced "a true viscous flow of the loaded littoral inward upon the unloaded "continent"; such a process might tend to form long parallel plications following the trend of the coast-line. The theory of isostasy however does not account

for the rise of the sea-floor and its conversion into a continental mass; in fact, as enunciated by Dutton, it tends rather in the opposite direction, and its author expressly stated that "the theory of isostasy offers no explanation of "these permanent changes of level."

So far as the Himālaya are concerned there are grounds for believing that isostasy is operative and has been an important factor in mountain-building, at least during the later stages of growth of the Siwālik range [Rev. O. Fisher: *Physics of the Earth's Crust* (1889), and C. S. Middlemiss: *Memoirs, Geological Survey of India*, Vol. XXIV, Part 2, 1889], but the hypothesis in its present form undoubtedly seems inadequate to account for the uplift of the northern ranges and of the Tibet plateau.

(c) *Change in the rate of the earth's rotation.*—The rate of the earth's rotation was formerly greater than it is now, and as the figure of a rotating body depends on its rate of rotation, any change in the latter will be accompanied by a change in the former. Retardation of the rate of rotation produces a more perfect sphericity, and tends to reduce both the excess of matter at the equator as well as the deficiency at the poles. The strains thus set up might produce a wrinkling of the crust, but can hardly be held to account for the general plication of the surface of the earth.

Other theories have been propounded to explain the origin of mountain ranges, but all are open to objections. Theories that attribute surface-folds to changes in the position of the earth's axis cannot be given any weight, for although such changes are known to take place, they have so far been found to be very small (Prof. Albrecht: *Astron. Nach*, No. 3619, abstracted in *Nature*, Vol. 58 (1898), p. 42). The theory ascribing the elevation of the sea-floor to the expansion, which it undergoes from heat when it becomes buried under layers of sediment, has been fully discussed and discarded by Middlemiss (C. S. Middlemiss: *Memoirs, Geological Survey of India*, Vol. XXIV, Part 2, 1890).

CHAPTER 8.

THE HIGH PLATEAUX OF ASIA, AND THEIR RELATION TO THE HIMĀLAYAN CURVATURE.

The Horseshoe.—The frontispiece to Part I illustrates the position and dimensions of the three high plateaux of Asia. The plateau of Tibet with an average height of 16,000 feet is joined at its north-western corner to the Pāmir plateau, height 12,000 feet, and this again is connected by mountains with the Tien Shan plateau, height 11,000 feet. The three plâteaux together assume roughly the shape of a horseshoe.

The interior of the horseshoe formed by the plateaux is an inland desert basin (*vide* Chart XXII) drained by the Tārīm river and its feeders; the sand of this basin is annually accumulating; the towns buried under the sand have become known throughout the world by the explorations of Sir Aurel Stein. The lowest part is the lagoon of Lop Nor (height 2,200 feet), and though there is no mountain range closing the horseshoe on the east, its opening here is narrow and the desert of Gobi beyond has a superior elevation of nearly 2,000 feet. On the north and west and south it is bounded by decomposing mountains, and no other portion of the earth has so gloomy a future. Unless geological changes ensue, the sand will continue to accumulate, until the lagoon of Lop Nor and the rivers of Tārīm are choked. The snow and ice which were accumulated upon the surrounding ranges during the last glacial epoch are slowly melting away and the volumes of the rivers are decreasing.

Chart IX has been drawn to illustrate the extraordinary parallelism that exists between the southern border of the Himālaya-Sulaimān ranges on the one side, and the northern border of the ancient mass of rock forming Peninsular India on the other.

The mountain ranges.—The height and length of a mountain range attract the attention of primitive people because they constitute a barrier to travel and an impediment to intercourse. So geographers have come to look upon great ranges of mountains as linear alignments of high summits and they show them upon small maps by simple lines. Of recent years, since the publication of Suess's Das Antlitz der Erde, geologists have been attaching much significance to the curved alignments that some mountain ranges assume, and geographers have considered it advisable to follow the geological lead, and to define their ranges not as linear but as curvilinear alignments. The great Himālayan range has been assumed by Suess and Sollas to be an arc of a circle the centre of which is in Mongolia. Whilst geographers may not agree with the conclusions drawn from the supposed arc, they realise the necessity of recognising the curvature of the alignment as a feature of the range.

The plateau of Tibet.—The plateaux of Tibet, the Pāmirs and the Tien-Shan seem to geographers to be conglomerations of ranges: several ranges, more or less parallel, constitute the framework of the plateaux and the flat portions of the plateaux are troughs between ranges which have become filled up with boulders, gravel and sand washed down from the mountains.

Reference has already been made to two of the dimensions of a range, its height and its length: its width, which is its third dimension, is less obvious and is in many cases undiscoverable without the aid of geological surveys. To residents of the plains of India the height and the length of the Himālayan snows are obvious but they know nothing of the width of the range. Even when a mountain range like the Karakorum has been surveyed, we cannot ascertain the width of the range at its base: geographers have in this matter to await the surveys of geologists. When therefore we say that the plateaux are conglomerations of ranges, we do not know how many ranges are standing compressed together in Tibet or the Pāmirs, nor do we know the depth of the alluvium that fills the troughs between the ranges.

Ranges vary in breadth, in places bulging towards one another, in places receding from one another, and the intervening troughs and flat plains become alternately narrower and wider.

"The immense extent of the existing alluvium in Tibet," wrote Henry Strachey, "and the uniformity of its maximum elevation lead me to infer that "it must have been deposited under a general sea covering the whole country, "and not by lakes, much less by rivers."

Henry Strachey thought that the alluvium had been deposited at the bottom of an ocean and afterwards upheaved to its present height without the horizontality of its layers being disturbed. Strachey's view agrees with the explanations put forward in recent years by Dr. Bowie of the United States Geodetic Survey, namely that a great deal of mountain formation has been caused by purely vertical uplift, and not by lateral pressure.

From fossil bones found at a height of 17,000 feet in Tibet, Colonel Godwin-Austen drew the conclusion that in recent times the climate which is now arctic must have been sufficiently warm to enable the rhinoceros and other tropical animals to live. "The only rational solution," he wrote, "which science could "suggest, was that within a comparatively modern period, closely trenching "upon the time when man made his appearance upon the face of the earth, "the Himālaya has been thrown up by an increment approaching 8,000 or "10,000 feet."

It is possible that the action of wind has helped to fill up the high-level basins of the plateaux with loess: this was the suggestion of Baron Von Richthofen. Those who have lived in the plains of northern India can testify to the enormous amount of dust carried annually by wind into the mountains. The finer particles of dust are lifted to very high altitudes and are probably trans-

ported for hundreds of miles. Wind may also help to distribute the dust that arises from the decomposing rocks of the plateaux themselves. These rocks are exposed by day to great heat from the direct rays of the sun, and by night to arctic temperatures; and their surfaces rapidly disintegrate under the influence of these changes.

The Tibet plateau has been always regarded as a barren country, but Kingdon Ward has discovered that south-eastern Tibet has a heavy rainfall in summer: north of Burma there is a breach in the Himālayan range, and the monsoon rushes through it. (*The Riddle of the Tsangpo Gorges,* 1926.)

The difference in the forms of neighbouring ranges may be realised if we compare the great Himālayan range with the Ladākh range situated to the immediate north. The snow peaks of the great Himālayan range can be seen stretching for 1,500 miles from Kashmīr to Assam; the Ladākh range has been traced in rear of the Himālayas from Kashmīr to Sikkim, and yet the Ladākh range in spite of its length is relatively small and insignificant. Morshead surveyed this range in rear of Mount Everest and Gauri Sankar and he described it as "insignificant." Compared with the Himālayan snows it is insignificant, but it cannot be said to be unimportant for notwithstanding its inferior height it is the main Himālayan watershed between Nepāl and Tibet; the Kosi and Gandak and Karnāli rivers which have cut back through the immense snowy range of Himālaya, rise in the minor range which appears so insignificant.

The Himālayan curvature.—The curvature of the Himālayan alignment, convex towards the south, has led to its being called the "Himālayan Arc" (Lake, *Geographical Journal,* 1931, p. 150) and has been regarded as evidence that the southern border of Tibet is advancing southwards towards India (Suess's *Face of the Earth,* Vol. I, 596).

The supposed southward advance of the Himālaya mountains is a geological problem, but as it is based upon a geographical fact, namely the curvature of the range, a geographer may be allowed to express an opinion. I do not think that it is justifiable to draw conclusions from the Himālayan range as if it were independent of Tibet, or to treat Tibet as if it were independent of the Pāmirs, the Tien Shan, the Hindu Kush, and the Sulaimān range.

These mountains constitute one geographical whole known as High Asia. The Himālayan range has, it is true, a curvature towards the south, but the Karakorum range, which has been called by Sven Hedin the backbone of High Asia, and which traverses central Tibet in rear of the Himālayan range, shows no such southward curvature, and in its western extremity in Hunza where it joins the Hindu Kush its curvature is convex towards the north. The northern range of Tibet, the Kunlun, has no decided curvature (see Chapter 16). If therefore the Tibet highland be regarded as a whole, it cannot be said to have a curvature towards the south. The elevated mass of the Pāmirs connects Tibet with the Tien Shan and there is no southward curvature in either. No

theory can be based upon a border range, unless it receives confirmation from the system as a whole.

The "deeps" of High Asia.—The mountains of High Asia stand in close contiguity to great crustal deeps: the Gangetic plains south of the Himālaya cover a crustal deep which has been shown by geodetic observations to extend downwards to great depths and to be filled with light alluvium.* The Takla Makān desert north of Tibet probably overlies another crustal deep: this has not yet been proved by geodetic observations, but some of the features of the Gangetic alluvium seem to be repeated in Takla Makān. It is probable that another crustal deep underlies Sistān in West Afghānistān. Vredenburg the geologist describes the "incredible thickness of the strata" in the Sistān alluvial deposits. (*Memoirs, Geological Survey of India,* Vol. XXXI, pp. 203, 206, 220; Survey of India, Professional Paper No. 17, 1918.) The Gangetic crustal deep and the Takla Makān and Sistān alluvial basins belong to the orographical system of High Asia: they are not mountains, but they are related to the mountains, and are the complements of the mountains.

Professor Meinesz has shown that there is a long zone, throughout which the crust is deficient in density and mass, outside Sumatra and Java (*Geographical Journal,* Vol. LXXVII, p. 323) similar to the deficiency observed on the Gangetic plains south of the Himālaya. He has explained this deficiency by assuming that outside the visible mountain range of Sumatra—Java there is a sub-crustal inverted mountain range which greatly exceeds the visible range in magnitude (Lake: *Geographical Journal,* Aug. 1931, p. 156). Meinesz's observations have certainly revealed a deficiency of matter underlying the crustal zone contiguous to the Sumatra—Java highlands: but the existence of a "sub-"crustal inverted mountain range" is hypothetical, and this hypothesis has been extended by suggestion to the Gangetic plains south of the Himālayas.

When the crust of the earth is compressed by horizontal pressure we understand how it becomes elevated into a fold, as the atmosphere above the crust offers only slight resistance to the elevation. But, if the crust is assumed to be compressed by horizontal pressure into a deep downward fold so as to form an inverted mountain range under the crust, we have to point out that if the resistance of the solid crust be taken into consideration, the density of the inverted fold would become greatly increased by the pressure at depth, and there would probably be no zone of deficiency. Deficiencies of density and of mass are not brought about by pressure.

The Gangetic deep not only skirts the foot of the great Himālayan range, but it extends far westward of the Himālayas and skirts the foot of the Sulaimān—Baluchistān range; on the east it extends into the Bay of Bengal towards Java and Sumatra. The hypothesis that a sub-crustal inverted mountain range is

* On the origin of the Indo-Gangetic trough, commonly called the Himālayan foredeep: *Proceedings of the Royal Society, Series A.,* Vol. 91, 1915.

underlying the crust from Baluchistān to Burma does not seem justified by the evidence available.

The excess of crustal mass that has been accumulated in High Asia.—The curvature of the Himālayan arc convex to the south has been held to show that the Himālayan mountain mass is being pushed southwards. The curved Irānian arc is supposed to denote a south-westerly advance of the Persian mountain mass, and the Japanese and Kurile arcs denote a movement towards the east. All these arcs are held to show an outward movement of the crustal mass from Central Asia. If the earth's surface was being pushed outwards by horizontal pressure from Central Asia we should expect to find a deficiency of matter at the centre of the continent. But what geographers do find in Central Asia is an excess of mountain mass, protruding above the spheroidal surface, which has nothing equal to it elsewhere on the globe. This unique excess of rock matter in Tibet, the Pāmirs and Tien Shan leads to the idea that the surface of the spheroid must have been distorted by pressures acting towards Central Asia and not outwards. The frontispiece chart of Part I of this book shows that the Himālayan curvature is repeated in rear of the Himālayas by the Ladākh and Kailās and Nyenchen-tang-lha ranges, but not by the great ranges of the Karakorum and Kunlun. It also shows that north of the Himālayan range and embraced within its curvature is the complex mass of Trans-Himālaya: no one can read Sven Hedin's account of Trans-Himālaya without being led to think that this mountain region has been subjected to compression not only in a meridional direction but also from the east and west. (See Hedin's *Southern Tibet*, Vol. VII, Chart LXXXIX.)

The Karakorum range attains its maximum height in western Tibet and there on either side of it we see the two deeps—the Indian deep and the Takla Makān deep—approaching nearer to one another and appearing to be compressing the Karakorum between them.

If the Himālayan arc were advancing southwards the Sulaimān arc must, from its similar curvature, be advancing to the south-east: so that the mountain ranges on both sides of the Punjab are according to these hypotheses approaching one another. If this were the case we should expect to find an excess of mass compressed in the crust between them. What, however, the geodesists do find is that the earth's crust between the Himālaya and Sulaimān ranges is deficient in density and mass, as if it had been opening and pushing the two ranges back. The problem is difficult and complicated; Dr. de Graaff Hunter has made an important contribution to the discussion from the geodetic point of view in the Geodetic Report of the Survey of India for 1929-1930 (page 55).

Recent advances in Geodesy.—In the 1907 edition of this book on Himālayan Geography and Geology, a chapter was devoted to the observations of the plumb-line and pendulum (Part II, p. 51). This chapter has been rendered out of date by recent advances in geodesy. The researches and results of Dr.

de Graaff Hunter, of Major E. A. Glennie and of Captain G. Bomford will require to be considered by all geophysicists who are investigating orographical problems. They are, however, based upon higher mathematics, and they cannot be explained in simple language. Modern geodesy though still a branch of geography is becoming specialised and difficult.

In the Geodetic Reports of the Survey of India, 1922 to 1930, Dr. Hunter has investigated the Figure of the Earth and the form of the geoid in India: he has also shown the "isostatic geoid" and the "compensated geoid". Major Glennie has defined these expressions (Geodetic Report V, page 57): Dr. Hunter and Captain Bomford have shown that Hayford's system of isostasy is not applicable to Peninsular India. Glennie's definitions and Hunter's and Bomford's criticisms of Hayford mark advances in higher geodesy. Major Glennie has brought forward a correlation between the geodetic results and the density of surface rocks: this is of particular interest, as the chief element of uncertainty in investigations of the geoid has been due to the varying densities of rocks. Whilst geodesists have always taken account of the difference of density between ocean and continent, they have never hitherto been able to allow for the difference of density between rock and rock.

The Tien Shan Plateau.

The Tien Shan consists of several ranges crowning a plateau, with alluvial plains in the intervening troughs. The main mass of the plateau south of Issiq Kol is 150 miles wide, and 11,000 feet high; the ranges separating the alluvial basins rise to 16,000 feet.

The ranges of Tien Shan tend to run in two directions at right angles to one another, whilst those of Tibet take but one direction and are generally parallel. "The two main directions of mountains in the Tien Shan," wrote Prince Kropotkin, "are south-west to north-east (that is, parallel to the fringe of the "great plateau of east Asia) and south-east to north-west, which direction is "taken by several ranges shooting off the Tien Shan. The former is the oldest, "the mountains following it have been lifted up during the palæozoic period, "while the other line of upheavals was relatively modern and attained its great-"est force during the tertiary and post-tertiary period." (*Geographical Journal*, Vol. XXIII, 1904.)

Colonel R. Schomberg explored the Central Tien Shan in 1928-1929. "Travelling in the Tien Shan," he writes, "is always peculiar because of the "truly prodigious number of passes that have to be crossed, and the reason is "always the same, namely the narrow deep canyons which are so persistent a "feature of this range. Travellers who complain of the narrow valleys of the "Himālaya would be greatly harassed by the gorges of the Tien Shan." (*Geographical Journal*, July, 1930, p. 33.)

We have seen in Part I of this book the difficulty that geographers have experienced in finding native names for mountain ranges in western and southern Tibet. The same difficulty is experienced in the Tien Shan: Colonel Schomberg says that the mountain people, though nomads, are too local in their outlook to invent a name for their mountains. The name Tien Shan is known to the Chinese, but not to the nomads.

The Pāmir Plateau.

The Pāmir mass (see frontispiece to Part I) is enclosed in the rectangle formed by the Hindu Kush, the Muztāgh Ata and Trans-Alai ranges; it is the connecting link between the Tibet and Tien Shan plateaux; it is the water-parting between two inland systems of drainage, one of which ends in the sea of Aral, the other in the lagoons of Lop Nor. (Northern Trans-frontier Sheet No. 2: scale 1 inch = 8 miles). Its elevated plains, like those of Tibet and Tien Shan, consist of horizontal accumulations of gravel deposited in rocky troughs.

The structure of the Pāmir plateau.—The ranges enclosing the alluvial troughs of Tibet are parallel to one another, and those of the Tien Shan are according to Kropotkin mutually perpendicular; the directions of the Pāmir ranges have not yet been determined. We do not know how the Muztāgh Ata and Sarikol ranges connect with the Tien Shan (see frontispiece to Part I), nor how the crustal folds of the Pāmir plateau trend west of the Sarikol range. We can form some idea as to the direction of the forces which elevated Tibet and the Tien Shan into wrinkles, but the Pāmir presents a more difficult problem.

Humboldt's conception of the Pāmir was a great meridional range connecting the Tibetan and Tien Shan systems, and this view was supported subsequently by Hayward and Wauhope: but Severtsoff and Fedchenko contended that the fundamental mass of the Pāmir plateau was a series of parallel ranges running from east to west.

The configuration of the Pāmir plateau.—The average elevation of the Pāmir alluvial plains is 12,000 feet, and that of the mountains dividing them 17,000 feet.

"Pāmir," wrote Stoliczka (Suess: *Das Antlitz der Erde*) "is not a plateau "at all: it is a congregation of chains."

"We may say," wrote Sven Hedin (*Through Asia*, page 185), "that the "Pāmir may be grouped into two sharply contrasted divisions, an eastern half "which is principally a plateau land such as I have described, and a western "half consisting of latitudinal mountain chains disposed parallel to each other. "There can be no doubt that at one period the entire region was strictly a "plateau and that it is being rapidly broken down by the agency of erosion."

"The meridional range," wrote Colonel Wauhope (extract from a letter) "forms "the eastern boundary of the Pāmir plateau; that range and the Hindu Kush are

"the dominating features of the region; the trend of the several ranges which "are being carved out of the original plateau is parallel to the Hindu Kush. "There is nothing on the west that can be called a meridional chain, though "the course of the Oxus is deflected in that direction by a great spur thrown "out from the Hindu Kush north of Tirich Mīr."

"Beyond the fact," wrote Lord Curzon (*Geographical Journal,* Vol. VIII, 1896) "that the general elevation of the Pāmir valleys is from 12,000 to 14,000 feet, "and that they are consequently at a higher level than the surrounding coun-"tries, there is nothing in their superficial character in the least degree cal-"culated to suggest a tableland or plateau, which I take to mean a broad "stretch of flat and elevated land, surrounded, may be, and even interspersed, "but not positively broken up, with mountain masses. Nor can anything "less like a down or a steppe be conceived than the troughs or valleys, of no "great width, shelving downwards to a river-bed or lake, and uniformly fram-"ed on either hand by mountains, whose heads are perpetually covered with "snow, which anybody who has been to the Pāmirs will at once recognize as a "fair description of those regions. In reality, over the entire region embrac-"ed by the title, it has been calculated that the plains or valleys constitute "less than one-tenth of the total area. Correctly described, a Pāmir in theory, "and each Pāmir in fact, is therefore neither a plain, nor a down, nor a steppe, "nor a plateau, but a mountain valley of glacial formation, differing only from "the adjacent or other mountain valleys in its superior altitude, and in the "greater degree to which its trough has been filled up by glacial detritus and "alluvium, and has thereby approximated in appearance to a plain owing to "the inability of the central stream to scour for itself a deeper channel."

Lord Curzon enumerates eight Pāmirs or alluvial plains:—

(i) The Taghdumbash Pāmir lies in the basin of the Tārīm, and north-east of the Kilik pass; it is 60 miles long and from one to five miles broad; it is drained by the Tashkurgan, a feeder of the Yarkand river.

(ii) The Wakhan Pāmir extends for 20 miles along the northern bank of the Wakhan affluent of the Oxus.

(iii) The Little Pāmir encloses lake Chakmaktin and follows the Aksu affluent of the Oxus for 60 miles. It is a long grassy plain varying from one to four miles in breadth.

(iv) The Great Pāmir encloses the lake of Sir-i-Kul; it is 80 miles long and varies in width from one to six miles; it is in the basin of the Oxus.

(v) The Alichur Pāmir lies north of the Great Pāmir and is in the basin of the Oxus. It contains the lake of Yeshil Kul.

(vi) The Sarez Pāmir is north of the Alichur Pāmir and in the basin of the Oxus.

(vii) The Rang Kul Pāmir containing the lake of that name lies north-east of the Sarez Pāmir; it possesses no drainage outlet.

(viii) The Khargosh Pāmir is north of the Sarez Pāmir and encloses the great Kara Kul lake; it possesses no drainage outlet.

CHAPTER 9.

GEOGRAPHICAL PROGRESS IN TIBET AND TAKLA MAKĀN.

On all sides of the Tibet plateau, rivers are cutting back into it by head erosion and the high level alluvial plains are only found intact in those portions which have not as yet been reached by feeders of the rivers. On the south and west the great rivers are confined to a few thoroughly drained troughs, and they can only expand their drainage areas now, if their upper feeders succeed in cutting back through the ranges of solid rock bounding the troughs. But on the east the rivers of China rise in the wide troughs of central Tibet and have before them the comparatively easy task of cutting back westwards into the soft alluvium, and of capturing for their basins long zones of the undrained portions of the plateau.

Western Tibet.—The Western portion of Tibet was surveyed under Colonel Montgomerie in the years 1855-65, and though many of its orographical problems still await solution, geographers have for years derived great advantage from Montgomerie's maps. In 1914 Sir F. de Filippi and Colonel Wood made surveys of the Depsang area, of the Rimo glacier and of the mountainous region beyond the Karakorum Pass, and these maps supplemented in 1926 by Major Mason's exploration of the Shaksgam Valley and of the head-waters of the Yārkand river, have proved a valuable addition to Montgomerie's work.* Sir Aurel Stein's surveys have extended over the western Kunlun and Takla Makān.

South-western Tibet.—The Mānasarowar lakes were surveyed by Henry Strachey in 1853, and his maps proved of great use for half a century until they were superseded by Colonel Ryder's admirable survey of 1904. (Exploration and Survey, Tibet Frontier Mission, *Geogr. Journ.* XXVI, 1905, p. 369.) The source of the Indus was not discovered till it was explored by Sven Hedin in 1907. ("*Southern Tibet*" Vol. II, p. 211.)

Southern Tibet.—The region between Sikkim and Lhāsa was mapped in 1904 by Ryder and Cowie of the Survey of India; Ryder fixed the peaks of the Nyenchen-tang-lha range.

In 1904 Ryder and Wood surveyed the valley of the Tsangpo in Tibet from the Yamdrok-Tso to Mānasarowar: they fixed the heights of the principal peaks on the Nepāl—Tibet watershed south of the Tsangpo, and on the mountain range north of the Tsangpo which was at that time called the Kailās range, but which has since 1908 been included by Sven Hedin in the mountains known as Trans-Himālaya.

Sven Hedin regards the Kubi-Tsangpo as the source of the Brahmaputra.

---

*(1) Spedizione Scientifica Italiana nel Himalaie Caracorum e Turchestan Cinese by de Filippi, 1923.
(2) Explorations in the Eastern Karakorum and Upper Yarkand by Wood, 1922.
(3) Exploration of the Shaksgam Valley and Aghil Ranges by Mason, 1928.
(4) Records of the Survey of India, Vol. XVII, 1923.

The Explorations of Sven Hedin, 1906-1908.—In the 1907 edition of this book it was recorded that large areas of Tibet were *terrae incognitae* (p. 66). Such a statement in 1931 is no longer correct. The explorations of Sven Hedin carried out continuously from 1906 to 1908 have given to the world a knowledge of Tibetan geography that has cleared up many uncertainties, and solved many of the former problems. He continued his explorations through winter and summer and the clearness with which he has recorded his scientific results is as remarkable as the perseverance he showed in the field.

The first book that he had published in English was entitled *Scientific Results of a Journey in Central Asia, 1899-1902.* He also wrote a popular account, *Through Asia,* in which he described the Muztāgh Ata peak and range, the Takla Makān desert and the Tsaidam region. In 1910 he published his book on Persia, *Overland to India.* The results of his explorations in Tibet, 1906-1908, were published in English at Stockholm under the title of *Southern Tibet: discoveries in former times compared with my own researches in 1906-1908* (dedicated to the Survey of India).

As all future Survey expeditions to Tibet will find it essential to study the explorations of Sven Hedin, I am recording for their assistance the subjects dealt with in the several volumes of *Southern Tibet :*—

Vol. I and Vol. II.—Lake Mānasarowar and the sources of the great Indian rivers.
Vol. III.—Trans-Himālaya.
Vol. IV.—Karakorum and Chang-Tang.
Vol. V.—Petrography and geology.
Vol. VI.—Meteorology, field astronomy and botany.
Vol. VII.—History of exploration in the Karakorum mountains.
Vol. VIII.—Tsang-Ling Mountains.
Vol. IX.—Eastern Pāmirs.

In 1929 Professor Emmanuel de Margerie published at Paris a handbook and review of Sven Hedin's explorations in Tibet. De Margerie's book will be useful to explorers: his final conclusion is that history will regard Sven Hedin as one of the greatest geographers of all time.

Like all advances in scientific knowledge, Sven Hedin's explorations in Tibet have opened up new geographical problems that will require solution by future explorers. One of the most interesting of these new problems is the connection of the great Karakorum range with the northern mountains of Trans-Himālaya. Another problem of interest to the Survey of India is the relationship of the Kailās range to the southern mountains of Trans-Himālaya.

A further great advance in knowledge,—an advance which like Sven Hedin's was due to the perseverance and enterprise of one explorer,—marked the first quarter of the 20th century; it was brought about by the explorations of Sir Aurel Stein between 1900 and 1915 in the desert regions north of Tibet.

On his first expedition, 1900-01, Stein was accompanied by surveyor Ram Singh of the Survey of India. On his second expedition, 1906-08, Ram Singh's health broke down and he had to be replaced by surveyor Lal Singh. The dangers encountered in the desert of Takla Makān arising from the loss of their tracks and of their bearings and from their difficulty in finding the water they had counted upon, produced in Stein and Lal Singh a mutual admiration for one another's courage and unselfishness which developed into a long friendship.

On his 3rd expedition, 1913-15, Stein was accompanied by surveyors Lal Singh and Mian Afraz Gul Khan. On these three expeditions Sir Aurel Stein made surveys of the Karakāsh and Yurungkāsh rivers in north-west Tibet and of the Muztāgh Ata range; also of the great Kunlun range, the northern wall of Tibet, from the Yārkand river to the Nanshan mountains. He also carried surveys along several lines across the Takla Makān desert from the Kunlun to the Tien Shan (see frontispiece chart, Part I).

Stein's archæological discoveries in Takla Makān were recorded in his four books:

1. The Ruins of Khotan, 1904.
2. Ancient Khotan, 1907.
3. Desert Cathay, 1912.
4. Serindia, 1921.

His geographical results were compiled with the aid of Major K. Mason, and were published by the Survey of India in 1923 as a Memoir on Maps of Chinese Turkistān and Kansu. The memoir bears evidence throughout of Stein's energy and Mason's enthusiasm.

Although Sir Aurel Stein belonged officially to the Indian Archæological Survey, his long association with the Survey of India has been a memorable event in the latter's history.

CHAPTER 10.

THE RANGES OF THE HIMĀLAYA.

The ranges of the Himālaya may be classified as follows (*vide* frontispiece to Part I) :—

(I) The Great Himālaya, a single range rising above the limits of perpetual snow.

(II) The Lesser Himālaya, a series of ranges closely related to the great range.

(III) The Siwālik ranges, which intervene between the Lesser Himālaya and the plains.

The Great Himālaya range.

The Himālaya is the name applied to the intricate and complex system of mountains that forms the northern boundary of India from Afghānistān to Burma.

The Himālayan area divided into five parallel zones.—The Great and Lesser Himālaya and the Siwālik ranges are so closely related that it may perhaps be desirable to commence with a general description of the area they cover. The outer zone of mountains, which is contiguous to the plains of India and which contains the small Siwālik range and the valleys in rear of it, was elevated more recently than the Himālaya: the width of this zone varies from five to thirty miles, being narrow in those places where the Siwālik range is jammed against the Lesser Himālaya, and wide where open valleys intervene.

The second zone is 40 or 50 miles broad, and is covered with mountains, that assume in the Punjab and Nepāl the form of longitudinal ranges running generally parallel to the great range. In Kumaun the form is more intricate: here the peaks of the second zone do not appear to follow distinct alignments of maximum elevation, but to be scattered throughout the region and to possess everywhere a remarkable uniformity of height between 6,000 and 10,000 feet.

The third zone is 10 miles broad, and is occupied by spurs projecting southwards from the great range; a few peaks of this zone exceed 15,000 feet in height.

The fourth zone contains the great line of snowy peaks. With the exception of the low ravines cut by rivers, the greater part of this zone is situated above the limits of perpetual snow. To an observer on the outer hills the Lesser Himālaya appear to vary but slightly in altitude throughout a wide area, but the Great Himālaya range to the north seems to rise suddenly like a wall of snow.

The fifth zone is about 25 miles broad, and contains the troughs of rivers rising behind the Great Himālaya. The average height of the beds of the

troughs is 14,000 feet and of the mountains intersecting them 19,000 feet; the average height of the zone is considerably less than that of the snowy zone.

The ranges covered with perpetual snow and the highest altitudes of the Himālaya occur about 90 miles from the southern limit of the mountains.

In the Charts XIV and XV seven cross-sections are shown; they have been drawn through the Himālaya at different points but always at right angles to the great range.

The age of the Himālaya.—The rocks of the Siwālik range are stratified and date from the latter half of the tertiary period; those of the outer Himālaya are stratified also but are very much older.

The central axis of the Great Himālayan range is composed of granite and gneiss; on either side of it are to be seen immense depths of sedimentary strata, which show that thousands of feet of rock have been removed from the crest-line. The granite solidified and cooled while below the surface of the earth, and its original covering has been worn away by the subsequent action of seas and rivers.

The Great Himālaya rose to be a mountain range in the same geological age as the mountains of Afghānistān and Baluchistān on the west and as those of Arakan and Manipur on the east. (*A Manual of the Geology of India, 2nd Edition*, page 494.) The immense depression of northern India, now filled with the alluvium of the Ganges and Indus, dates from the same period as the elevation of the Himālaya.

Though the whole length of the Great Himālaya range belongs to one geological age, yet the Punjab Himālaya are supposed to have risen at a somewhat later date than the Nepāl Himālaya. The presence at elevations of 16,000 feet in the Punjab Himālaya of nummulites indicates that this portion of the range did not emerge from the sea till comparatively recently.

Bifurcations.—The direction of the Great Himālaya range does not bend with a uniform curvature, but follows different alignments. As it bends from west to north-west it frequently bifurcates and throws off minor ranges on the convex side of the bends. At each bifurcation the minor range tends at first to continue in the alignment which the great range is forsaking; it gradually, however, turns and finally runs parallel to the new alignment of the great range.

The total length of the Himālaya divided into four sections.—For purposes of geography the great range has been divided into four parts,—the Assam Himālaya, the Nepāl Himālaya, the Kumaun Himālaya, and the Punjab Himālaya. Whilst in all four parts the great range rises like a wall and the outer ranges tend to run parallel to it, no one portion of the Himālaya resembles another.

In Nepāl we find numerous rivers cutting across the Great Himālaya range; in the Punjab between the Sutlej and the Indus we do not find one. In Nepāl

the great peaks stand in clusters and rows; the great peak of the Punjab stands in solitude.

The differences between different Himālayan regions show how impossible it is to deduce general laws from the study of one area.

The total length of the Great Himālaya range from Namcha Barwa to Nanga Parbat is 1,500 miles; and the lengths of its four sub-divisions are as follows:—

Assam Himālaya 450 miles.
Nepāl Himālaya 500 miles.
Kumaun Himālaya 200 miles.
Punjab Himālaya 350 miles.

Assam Himālaya.—The Assam Himālaya form the easternmost section of the Great Himālayan range: they extend from the river Tīsta in Sikkim, across the Brahmaputra towards China. In the 1907 edition of this book, it was recorded that "the highest points of the Assam Himālaya are the twin peaks "of Kula Kangri." (Table V, Part I.) The Kula Kangri peaks are 150 miles east of Kānchenjunga. In 1912 a new peak named Namcha Barwa (height 25,445) was discovered 300 miles north-east of Kula Kangri, and in 1913 Captains Morshead and Bailey discovered the peak of Gyala Peri (height 23,460 feet) situated north of Namcha Barwa and on the opposite side of the Brahmaputra. By these discoveries the known length of the Assam Himālaya has been increased to 450 miles.

Hitherto the Assam Himālaya have not attracted the same attention as the other sections of the Himālaya. They had had no place in Indian history, and had not been explored by Aryan pilgrims: no Indian temples had been erected on their rivers, no Sanskrit names had been given to their peaks. No Aryan languages are spoken in the Assam Himālaya: along their northern zone the geographical names are Tibetan: and in other parts the names are Tibeto-Burman (see Appendix, Part I).

The discovery of Namcha Barwa, a peak almost as high as Nanda Devi, has awakened a new interest in the eastern section of the Himālayan range. The exploration of the Assam Himālaya by Morshead and Bailey covered 3½ degrees of longitude—from 91° 30′ (Bhutān) to 95° (Mishmi country). Their surveys brought to light serious errors in the representation of the river Tsangpo upon maps: on the evidence of earlier explorers, who had not been trained surveyors, we had made the Tsangpo change its direction from Tibet across the Himālaya towards Assam in longitude 94°: Morshead places the knee-bend of the river 65 miles further east in longitude 95° 15′. From latitude 30° to 28° the course of the Dihāng (Brahmaputra) is not south-east as formerly drawn, but south. In Chapter 9 reference was made to the southward curvature of the Great Himālaya range: Kānchenjunga marks the southernmost point of the Himālayan curvature: westwards from Kānchenjunga the Nepāl Himālaya trend to the WNW.: eastwards of Kānchenjunga the trend of the Assam Himālaya is ENE., approximating to NE. at the Brahmaputra.

In the Assam Himālaya Morshead discovered six glaciers and one important lake. Five of the glaciers were on the slopes of Namcha Barwa and one was flowing south from the peak of Gyala Peri. The Sanlung glacier of Namcha Barwa, which is the largest, descends to within a mile of the Tsangpo, the height at the foot of the snout being 9,000 feet. The glaciers bore evidence of slow but prolonged retreat. Pines of 30 years growth were seen a quarter of a mile below the present limit of the ice.

The lake which Bailey and Morshead discovered was the Yigrong Tso. The latter learnt the history of this lake from the villagers. About the year 1900 a tributary of the Yigrong river ceased to flow for three days, and rumblings were heard up the valley. Suddenly in the afternoon a mass of mud and stones came down the valley, burying four villages, and forming a dam across the river 350 feet high. The material was so hot as to blister the feet of anyone who walked on it.

For a month the Yigrong river was dammed, and a huge lake was formed. Eventually the dam was topped, and the water released to form a flood which was noticed in Assam as carrying the corpses of strange men and of pine trees of an unknown variety. The lake to-day is ten miles long and a mile wide in some places. Morshead thought that this story of the origin of the Yigrong lake furnished the explanation of the flood of 1900 on the Dihāng river.

The Assam Himālaya do not end at Namcha Barwa: the range crosses the Brahmaputra and runs north of Burma towards China. Morshead saw a sharp range of snowy mountains twenty-five miles north-east of Namcha Barwa, and Kingdon Ward has observed this range also.

In Volume IV of the Records of the Survey of India, 1914, reference was made to the absence of geographical knowledge of the mountain area between the Brahmaputra and the Yang-tse-kiang, between Tibet and Burma. In recent years the explorations of Captain Kingdon Ward from China have shown that within this region of dense jungle, precipices and torrential rivers, the highest mountain range of the globe is breached by a wide gap before it comes to an end. (*From China to Hkamti Long*, by Kingdon Ward.)

In 1924 Captain Kingdon Ward entered Southern Tibet again, and on this occasion through Sikkim; accompanied by Lord Cawdor he reached the Tsangpo at Tsetang, fifty miles south-east of Lhāsa. The two explorers then followed the Tsangpo eastwards, and skirting Morshead's peak of Gyala Peri they penetrated the Tsangpo gorge between Gyala Peri and Namcha Barwa. Kingdon Ward doubts whether it is correct to regard Gyala Peri as a Himālayan peak: of Namcha Barwa he has no doubt. On their return journey Ward and Cawdor crossed the Assam Himālaya through Bhutān. (*The Riddle of the Tsangpo*, by Kingdon Ward.)

Considerable interest has been aroused by recent reports of the Tatsienlu snow mountains, which are situated four hundred miles east of Namcha Barwa.

The curvature of the Himālayan alignment gives to the eastern section of the Himālaya a north-easterly trend, and if we draw a line towards China in direct continuation of the Assam Himālaya, it will pass a very long distance north of Tatsienlu.

In 1898-99 Colonel Ryder made surveys of Yunnan (south-west China). He marched in an easterly direction from Batang in south-eastern Tibet to Tatsienlu. (*Geographical Journal,* February 1903.) Batang is only two hundred miles east of Namcha Barwa. Ryder saw no snow mountains either at Tatsienlu or elsewhere. The Tatsienlu mountains may have been hidden from him by clouds, but his observations from Batang onwards furnish strong evidence against the existence of an easterly extension of the Himālayan range as far south as Tatsienlu.

All the information available concerning the Tatsienlu high peaks was collected by the editor of the Geographical Journal and published by him in April 1930. He summed up the geographical position in the statement that our knowledge of the mountains near Tatsienlu is very defective. Kingdon Ward is quoted by him as saying that it is extremely unlikely that Minya Gongka exceeds 25,000 feet. Minya Gongka is believed to be the highest mountain visible from Tatsienlu.

The Nepāl Himālaya.—The Nepāl Himālaya stretch from the Tīsta to the Kāli, and carry the peaks of Everest, Kānchenjunga, Makālu and Dhaulāgiri. The great range bends and bifurcates near Dhaulāgiri (see figure 1, Chart XVI). West of Dhaulāgiri (26,795 feet) the height of the range diminishes, and throughout the wide basin of the Karnāli the highest peaks do not rise above 22,000 feet; near the western edge of the basin there is the Api-Nampa cluster of peaks.

Not far from Nampa there is a second bifurcation of the great range (figure 2, Chart XVI). At all the other Himālayan bifurcations the more northerly branch has been regarded as the continuation of the great range, but from Nampa the southerly branch, carrying Nanda Devi (25,645 feet) and Badrīnāth (23,190 feet) has been assumed to be the Great Himālaya, and the northerly branch carrying Kāmet (25,447 feet) and Riwo Phargyul (22,210 feet) to be the Zāskār range.* After the Nampa bifurcation the southern branch is so large and carries such high peaks, that the northern is obscured from view from the side of India: but at all other bifurcations the northern branch remains the more important, and the more remarkable to Indian observers. *Himālaya was the name given by the Hindus to the snowy range visible from India.*

The Survey of India has not had many opportunities of taking observations in Nepāl. In 1903 Colonel Wood observed Gauri Sankar and Mount Everest from the side of Nepāl, from stations near Kātmāndu: in 1907 Natha

---

* Kāmet is seventeen miles in rear of Badrīnāth, the Vishnuganga flowing between. Atlas Sheets 65 and 66: scale 1 inch=4 miles.

Singh took a plane-table traverse along the Sun Kosi river to the southern slopes of Mount Everest. And between 1921 and 1924 much topographical knowledge of the northern slopes was gained by the three Mount Everest expeditions which were organised by the Royal Geographical Society and the Alpine Club. On these expeditions vigorous attempts were made by experienced mountaineers to climb the mountain, and on June 8th, 1924, Mallory and Irvine almost succeeded in reaching the summit; but they lost their lives in the attempt, and it was beyond the power of their colleagues to discover how far they were from their goal when they died.

Ascents to 28,000 feet were also achieved by Colonel Norton, R.H.A., and Dr. Somervell, whilst a height of 27,000 feet was attained on two occasions by Mr. Odell. The history of these expeditions was recorded in three books, namely :—

(1) Mount Everest: The Reconnaissance, 1921.
(2) The Assault on Mount Everest, 1922.
(3) The Fight for Everest, 1924.

There is also a summary account, "The Epic of Mount Everest," by Sir Francis Younghusband.

Two officers of the Survey of India were attached to the first Mount Everest expedition in 1921, Colonel Morshead and Major Wheeler. They made full use of their opportunities; Morshead carried out a topographical and reconnaissance survey of the region, and Wheeler triangulated the mountain area and was able to determine the positions and heights of several peaks in the vicinity of Mount Everest: his triangulation has been a valuable contribution to Himālayan geography.

Hodgson's views.—In 1849 Brian Hodgson, the celebrated naturalist, who was then the political resident in Nepāl, advanced a theory, which is illustrated in Chart XII. The great Himālayan peaks, he maintained, did not stand on a range of mountains, but on spurs projecting from the Tibetan range behind. Mr. Hodgson devised his theory to account for two phenomena, *viz.*, (*i*) that the great peaks are not standing on a main water-parting between India and Tibet, (*ii*) that the Himālayan rivers tend to converge inside the hills instead of flowing at right angles to the high mountains in a great number of parallel courses.

Mr. Hodgson's arguments can be answered as follows :—the great Himālayan peaks are not connected by spurs with the Tibetan range, but are separated from it by troughs; the great peaks are not limited to the ridges between river-basins as drawn by Mr. Hodgson, but stand in a long line which intersects the basins; the Himālayan rivers have not been forced to converge by lofty lateral spurs, but by the recent upheavals of the outer parallel ranges

(The recent Survey of Nepāl is described in Part III, Chapter 21).

which have barred the paths of rivers and forced them to combine within the hills.

The Kumaun Himālaya.—The Kumaun Himālaya stretch from the Kāli to the Sutlej; the highest peak is Nanda Devi (25,645 feet). There are bifurcations at Badrīnāth and at the Sutlej (see Chart XVI).

After the bifurcation at Nampa the width of the great range becomes less and its altitude greater; after the bifurcation at Badrīnāth (see figure 3, Chart XVI) the width becomes greater and the altitude less.

The upper surface of the Kumaun Himālaya appears to be corrugated. The Gangotri glacier, for example, at the source of the Bhāgīrathi flows for 16 miles along a trough in the crest-zone of the great range (see Chart XXIV, Part III). The mean altitude of its surface is 14,000 feet, and there are peaks of 22,000 feet on either side within 2 miles of it; its trough is parallel to the axis of the great range. The view of the Great Himālaya, that is obtainable from the plains of India or from the outer hills, conveys the impression that the snowy range possesses a narrow and sharply-edged crest-line, but this idea is incorrect: the summit of the range is several miles broad, and the great peaks stand in a wide zone. To a distant observer the snowy range east of the Sutlej appears to resemble the edge of a saw, but its crest-zone measures 30 miles in breadth.

The Kumaun Himālaya and the adjoining part of Tibet have been well described by Mr. C. Sherring, I.C.S., in his book "*Western Tibet and the British Borderland,*" 1906. This book gives much geographical and ethnological information; it gives clear descriptions both of the country and of its people, their different races, their origins, and religions; Dr. Longstaff has contributed to it an interesting account of his attempt to climb the high peak of Gurla Mandhāta.

An accurate picture of the higher regions of Kumaun has been given in Mr. A. Mumm's book "*Five months in the Himālaya.*"

The Punjab Himālaya.—The Kumaun and the Punjab Himālaya do not follow the same alignment, owing to curvature; they are now separated by the defile of the Sutlej, which cuts across the range where the curvature is sharp. An important bifurcation occurs here (figure 4, Chart XVI). After the bifurcation at Dhaulāgiri the elevation of the range diminishes, and a similar diminution occurs after the bifurcation at the Sutlej. East of Dhaulāgiri there are peaks exceeding 26,000 feet, west of it but few peaks rise to 22,000 feet. East of the Sutlej the Kedārnāth, Jaonli and Badrīnāth peaks stand above 22,000 feet, but west of the Sutlej few peaks exceed 20,000 feet. We have already seen that as a range bends, it bifurcates, and now we see that it changes its form after bifurcation.

The characteristics of the great range are so different on the two sides of the Sutlej that doubts as to its original continuity have been expressed: our

maps show one range meeting the Sutlej from the east, and two, if not three, smaller ranges leaving it on the west. For a comparison of this break in the range with similar breaks in the Hindu Kush, see Part II, Chapter 14.

The difficulty of determining the original lines of structure is increased by the presence of the extraordinary Narkanda-Mahasu ridge that runs diagonally across the Himālaya from the high snows to the low plains: this ridge is not cut across by any river, and its unbroken uniformity of descent is only equalled by that of Singālila. It forms the southern boundary of the basin of the Sutlej, and it was regarded by Mr. Fraser in 1820, by Captain Herbert in 1821, and by Captain Gerard in 1822 as the real termination of the great Himālaya of Kumaun and Nepāl.

The bifurcating branch at Badrīnāth becomes the Dhaulauchār range of the lesser Himālaya, that at the Sutlej becomes the Pīr Panjāl range of Kashmīr. The Dhaulauchār, the Pīr Panjāl, the Punjab Himālaya and the Zāskār ranges are all secondary undulations superposed on one flat broad arch, the span of which reaches from the plains of the Punjab to the Indus in Tibet.

Near the centre of the Punjab Himālaya the range culminates in the Nun Kun peaks* (23,410 and 23,250 feet) which stand 3,000 feet above the crest.

The water-parting of the Punjab Himālaya follows an exceptionally straight line from the Sutlej to the Nun Kun peaks, and again from those peaks onwards, but at the peaks themselves it exhibits a double sinuosity, which is illustrated on Chart XXXIV of Part III. North-west of the Nun Kun peaks the crest-zone is in places corrugated.

The northern and southern slopes of the Punjab Himālaya are very different in form and character; the northern are bare and stony, but contain lakes and high plains, the southern are forest-clad but are seldom level.

In the Nepāl and Kumaun Himālaya there are many river gorges piercing the granite range, but no river crosses the Punjab Himālaya. The Zoji La, however, is a remarkable feature of the latter. This pass across the great range is only 11,300 feet high, and is consequently below the level of the troughs that lie in rear of the Nepāl Himālaya. "Such a depression elsewhere would "have been sufficiently deep to open a passage for the drainage of the table-"land, but the great depth of the valley further north, in which the Indus "flows, gives the waters a more favourable escape in that direction." (Sir Richard Strachey's *Himalaya*: *Encyclopædia Britannica*, Vol. XI.)

Though the Zoji defile was probably carved out of the range by a pre-historic river, it is now a true pass, that is to say, it crosses a water-parting line, and from its summit streams descend in opposite directions. The descent from the Zoji is very steep on the side of Kashmīr, but is gentle on the side of Ladākh: the pass itself is grassy, and so level for half a mile that the exact water-parting

* Ser and Mer, *vide* Table VII of Part I. For an exploration of the Nun Kun group see Hunter Workman's address, *Geographical Journal*, Vol. XXXI.

line is difficult to discover. Peaks rise immediately on both flanks of the pass to 14,000 feet, and then gradually to 16,000 and 17,000 feet.

Colonel Tanner wrote (*General Report, Survey of India*, 1878-79), as follows of the country between the Indus and the Kunar (see frontispiece to Part I):—

"The central backbone may be described as a huge broken tableland running up into wave-like ridges, which rise but a few hundred feet above the general level of the range. The ridges and peaks on the central backbone are all of nearly the same height, and are very similar to each other in appearance, and consequently not easy to identify from points more than a few miles apart. For this reason neither my surveyors nor myself have been able to fix with accuracy any points on the watershed, nor the passes which lead over the range, though several have been determined approximately. It is not I only who have experienced a difficulty here, for the Great Trigonometrical Surveyors, when prosecuting the Kashmīr triangulation, though they have fixed peaks far away even in the very heart of Kāfiristān, have failed to determine more than two or three points on the entire watershed, a distance of nearly 150 miles. From the beginning of September the great ocean-like expanse of wavy ridges was snowed up."

At a subsequent date Colonel Tanner referred again to the same region. "We have now obtained," he wrote (*General Report, Survey of India*, 1879-80)* "nearly all the topography of that remarkable region, which is situated on the northern slope of its ill-defined watershed, and to the eastward a small portion of the southern slope as well. It is an immense tangle of exceedingly sharp ridges, which zigzag about in the most perplexing manner. There are hundreds of peaks of nearly the same height and so like each other that after moving a few miles they cannot be recognised. One very marked feature in this range is the extraordinary number of mountain lakes or tarns, which are found as many as three or four together at the sources of all the small feeders."

Mr. Lydekker has also referred to the uniformity of elevation which prevails in the region north-west of the Indus. "A remarkable feature," he wrote (*Memoirs, Geological Survey of India*, Vol. XXII, 1883), "along the Indus valley in Darel, for the notice of which the writer is indebted to Lieutenant-Colonel Tanner, is that all the peaks over a considerable area reach to a nearly uniform height of about 21,000 feet; thus apparently leading to the conclusion that this level indicates an old plain of marine denudation, originally bordered by higher ground of which the peaks of Nanga Parbat and Rakaposhi reaching to over 26,000 and 25,000 feet are remnants."

* The following extract is also from Colonel Tanner's Report for 1879-80: "When I say that I have fixed 145 hill peaks, I do not wish it to be understood that the points have the accuracy of those hitherto accepted by the Great Trigonometrical Survey. The apexes of some of my triangles are so acute that an error of one minute at either of the ends of the base would make an error of ten miles in the position of the point. I hope however at some future time to be able to improve the shape of the triangles, so that my points shall be true to a tenth of a mile."

Ninety miles of the crest-zone of the Nepāl Himālaya carry peaks exceeding 24,000 feet: the twin peaks of Nanda Devi are the only points of the Kumaun Himālaya that rise above 24,000 feet, and the peaks of Nanga Parbat the only points of the Punjab Himālaya.

Trigonometrical surveyors have thus not been able to trace by means of heights the continuation of the Great Himālayan axis beyond the Indus. Recent geological surveys by Mr. D. N. Wadia have established the fact that the tectonic fold-lines of the Himālaya are doubled back upon themselves in a great hairpin bend parallel with the course of the Indus. [*Records, Geological Survey of India,* Vol. LXV, part 2, pp. 189-200 (1931)]. This extraordinary inflexion affects a depth of some three hundred miles into the mountains, from the foot-hill zone right through the central axis of the Great Himālaya to as far north as the foot of the Pāmirs (Lat. 37°N.). (See Chapter 25 of Part III.)

If the terminology of mountain-ranges depended entirely upon their geological structure, the point at which one would wish to end the Great Himālaya range is where the fold-axes wrap round this re-entrant, so that the Murree hills would not, if purely geological reasoning prevailed, be regarded as a part of the Himālaya. The Karakorum and the Kailās ranges also show a parallelism with the direction of the fold-axes.

The view of the joint authors of this work is that the primary consideration in the nomenclature of the course of mountain-ranges is orography, and that the trend of a chain may, or may not, coincide with continuous geological fold-axes. If one looks at the orographical map instead of the geological map, one finds that the country occupying the great re-entrant is not low-lying, as might be expected from the fact that younger sediments are exposed in its core than on its flanks. The Great Himālaya should, on this contention that orographical considerations prevail over geological, be terminated where a general fall in altitude takes place, and this would appear to be conveniently taken to be at the Indus valley.

Passes over the Great Himālaya.—If complete maps existed of the Himālaya, the whole area would be found to be dotted with passes: the number of passes runs into thousands and no attempt has been made in this paper to compile a catalogue.

Passes do not as a rule possess any scientific interest; they are mostly situated on the crests of spurs and minor ridges, and are seldom found upon the axes of the great ranges. We will take the cases of a few well-known passes to illustrate our meaning. The Tipta (15,600 feet), for example, is a much-frequented pass of eastern Nepāl, but it has no geographical significance; it is situated on the crest of a southern spur of the Great Himālaya,—a spur that has been carved altogether by water,—and it allows travellers to cross from the valley of the Tamur Kosi to that of the sister-river the Arun. The Rohtang pass (13,050 feet, Chart XXXII) and the Hamta (14,000 feet) cross the eastern

section of the Pīr Panjāl range between Kulu and Lahaul and are on the water-parting between the Beās and Chenāb. The Buran Ghāti* (15,016 feet) and the Shatul (15,555 feet) cross the eastern section of the Dhaula Dhār range south of the Baspa. The Kamri (13,250 feet) and the Burzil (13,775 feet) cross weather-worn ridges north of Kashmīr. Even the Manirang (18,600 feet), south of the Spiti basin, and the Bāra Lācha (16,047 feet), north of Lahaul, cannot be regarded as crossing the Great Himālaya.

In the Nepāl and Kumaun Himālayas, travellers pass from India into Tibet along the channels of the great rivers: these channels, difficult though they are, furnish readier means of access than mountain paths above the snow, and passes over the range are consequently not necessary. The defile of a river is sometimes regarded as a "pass," but when entered upon a map, the word "pass" almost always denotes the highest point of a path, with an ascent to it from one side and a descent from it on the other.†

The Bhote Kosi and Dudh Kosi rivers (Chart XXVIII) rise in the Great Himālaya range but north of its axis, the former at the Thanglang pass (18,460 feet), the latter at the Pangula (20,000 feet). These passes are the highest points of routes connecting Nepāl and Tibet, but they are not situated on the axis of the great range, being 30 or 40 miles in rear of it. The rivers have cut down the axis and the passes cross only the northern flank of the range. Similarly the passes into Tibet from the Tīsta basin, the Kongra (16,900 feet), the Naku (18,186 feet), the Dongkya (18,100 feet), are over the northern flank of the great range but not over the axis; the Tīsta has carved a bay out of the range behind the axis and the passes lead over the northern edge of the bay. The Tang La (15,200 feet), however, near Chomo Lhāri at the head of the Amo Chu valley, is a pass over the axis of the great range itself.

The Punjab Himālaya, not having been pierced by rivers, furnishes more examples of passes crossing the axis than the mountains of Nepāl and Kumaun. A notch in a range does not become a "pass," until it is frequented by travellers, and though notches in Nepāl are probably as plentiful as in the Punjab, they are not used as passes. In the Punjab the absence of river-gorges through the range obliges men to cross the crest-line, if they wish to enter Tibet, and several passes, of which the Zoji (11,578 feet) is the best known, do traverse the axis of the great range.

The Siwālik range.

The Siwālik or Sivalik range of hills is considered in Hindu mythology as the edge of the roof of Siva's dwelling in the Himālaya. The name "Siwālik" was mentioned by the Emperor Bābar in his Memoirs, A.D. 1528. This low

* The "Boorends" of Gerard, 1821.

† The English word "pass" denotes any narrow passage. The Afghān word "Kotal" and the Tibetan word "La" denote the highest point of a mountain path, with an ascent to it on one side and a descent from it on the other. The topographical *symbol* for "pass" is only applied on maps to *Kotals* or *La-s*, but the word "pass" has been applied also to long river beds like the Khyber and Bolān.

but very long range separates the Himālayan mountains from the plains of India. Topographically it belongs to the mountains, geologically it belongs to the plains. It is the southern border range of the Tibet mountain system.

Though its upheaval was accompanied by movements of the Himālayan mountains themselves, and probably by increases in the latter's elevation, yet the Siwālik range is of more recent formation, and is, perhaps, the most recently formed range of similar magnitude on the earth.

With the exception of a short distance of 50 miles, opposite to the basins of the Tīsta and the Raidak, the Siwālik range has been shown by geologists to skirt the Himālaya throughout their length with remarkable uniformity for 1,600 miles, from the Brahmaputra to the Indus and even to the west of the Punjab.

At the passage of the Sutlej there is a break—not a bend—in the alignment and the two lengths of range appear to overlap. Figure 2 of Chart XIX shows how the range north of the Sutlej is not a direct prolongation of the one to the south.

Its "dūns."—In places the Siwālik range is pressed against the outer Himālayan ranges, and its existence would be overlooked by the casual observer: in other places, it is separated from the Himālaya for distances of 20 or 50 miles and encloses canoe-shaped longitudinal valleys called "dūns." The best known of these is the Dehra Dūn, that stretches from the Ganges to the Jumna: deposits of rounded stones, gravel and sand have been brought down to the Dehra Dūn from the Himālaya and have raised its surface 1,000 feet above the level of the plains beyond the Siwāliks. Other dūns near Kumaun are the Kotāh, Patli, Kothri, Chgumbi, and the Kiārda, and many exist in Nepāl; but they are not found north of the Rāvi.

A bifurcation.—The Siwālik range is strongly developed opposite the Dehra Dūn with steep southern slopes and gentle northern: near the centre of this dūn the range bends through an angle of 40 degrees, a similar bend being observable in the outer Himālayan range, 15 miles to the north. On the convex side of its bend, following the example of its great Himālayan neighbour, the Siwālik range threw off a branch range, remains of which are still visible in the hill of Nāgsidh (see figure 3 of Chart XIX). As is a common occurrence in the great Himālaya, the Siwālik range is crossed by a defile at the very point of its bend.* Figure 1 of Chart XIX illustrates another bifurcation in the Siwālik range.

Its rocks.—The Siwālik range is composed of the same material, hardly consolidated, that forms the deposits of the level plains of northern India. The Siwālik zone was formerly the northernmost belt of the flat alluvial region: it has been compressed by lateral forces into a long fold or range.

* The defile is the Mohand pass, see Atlas sheet 48 N. E.; also see sheets of the Dehra Dūn and Siwālik Survey.

The thickness of the strata in the Siwāliks exceeds 15,000 feet; these immense deposits were all brought down by the Himālayan rivers, and upheaved in recent times. The rocks of the Siwāliks are entirely of fresh-water origin and prove that the sea has not washed the base of the Himālaya since the Eocene period. (Vide *Physical Geology of the Sub-Himālaya of Garhwāl and Kumaun,* by C. S. Middlemiss: *Memoirs, Geological Survey of India,* Vol. XXIV, 1890.)

The Lesser Himālaya ranges.

The Great Himālaya and the Siwālik ranges are two long parallel folds of the earth's crust,—about 90 miles apart from axis to axis (Charts XIV and XV). The region enclosed between them is occupied by the intricate system of ranges we have called the Lesser Himālaya. If we allow for the widths of the Great Himālayan and Siwālik ranges themselves, the zone occupied by the Lesser Himālaya averages perhaps 50 miles in width.

The contortions of the strata show that the Lesser Himālaya region has everywhere been compressed horizontally. These mountains are however the result not of one but of many movements of the crust, and their history is more complex than that of the Siwāliks: ranges have been uplifted, and have been afterwards forced to change direction: the whole region has been subjected to successive compressions, and the general wrinkling process is probably still continuing.

In Kashmīr and parts of Nepāl, where outer ranges are distinct, flat alluvial valleys are enclosed behind the Lesser Himālaya, like the "dūns" of the Siwālik and like the plains of Tibet, but in Kumaun, though rivers may run for miles parallel to the mountain axes, the longitudinal and high level alluvial valleys are absent.

If we attempt to analyse the lesser Himālayan ranges, we find that they can be divided into two classes: (*a*) those that branch from the Great Himālaya, (*b*) those that are separate folds. The branch ranges of the first class run obliquely across the mountain area; the separate folds of the second class follow curvilinear alignments parallel to the great range.

The great range bifurcates generally at the points where it is changing its alignment, and each successive branch range adopts the alignment, which the trunk range is forsaking. Having traversed the mountain area obliquely the branches slowly alter their direction and finally run parallel to the great range.

We may classify the seven known ranges of the Lesser Himālaya as follows:—

the Nāg Tibba,
the Dhaula Dhār,
the Pīr Panjāl,
the North Kashmīr.

These four ranges are oblique and are separate branches of the great range.

The three outer ranges, which may or may not be different sections of one long range, are—

the Mahābhārat,
the Mussoorie,
the Rattan Pīr.

THE NĀG TIBBA RANGE.

The most easterly oblique range that is known to us, branches from the Great Himālaya near Dhaulāgiri (figure 1, Chart XVI) and runs at first in prolongation of the great range's alignment. It continues in a straight line strongly developed across the basin of the Karnāli; it passes through Almora, Nāg Tibba and the Chaur,* and conjoins with the Dhaula Dhār range near the Bara Bangahal (Chart XVIII). For over 100 miles in Kumaun this range is without a break, and it compels the Alaknanda, the Pindar and the Sarju to flow parallel to it along its northern flank: the Alaknanda and Pindar rivers combine to pierce it north of Hardwār, and the Sarju combines with the Kāli to pierce it near the western border of Nepāl.

Twenty-four miles west of Dhaulāgiri (26,795 feet), the highest peak of the Nāg Tibba range is 23,750 feet: at 52 miles the highest peak is 19,875 feet, at 70 miles 15,000 feet, at 96 miles 12,000 feet;† south of the Pindar river its peaks are 9,000 feet. These figures indicate how the branch declines in height on separating from the trunk range.‡

THE DHAULA DHĀR RANGE.

The second oblique range branches from the great range near Badrīnāth and runs south of the Baspa tributary of the Sutlej. It is cut in two by the Sutlej at Rāmpur and by the Beās at Larji; and it is crossed by the Rāvi south-west of Chamba. The northern flank of the Dhaula Dhār range impinges against the southern flank of the Pīr Panjāl range at the mountain knot of Bara Bangahal.§ The bifurcation near Badrīnāth is illustrated in figure 3, Chart XVI, and the conjunction of flanks at the source of the Rāvi in Chart XVIII.

THE PĪR PANJĀL RANGE.

The Punjabi and Kashmīri people apply the name Pīr Panjāl to the range, but it originated with the Pīr Panjāl pass. The old road of the Mughal Emperors passed over the Pīr Panjāl pass. Sir Aurel Stein has explained that in Kashmīr

* The Chaur is a remarkable double peak (11,966 feet) twenty-five miles south-east of Simla. It is composed of granite and is supported by seven buttresses. It exceeds in height by 1,500 feet all points within thirty miles of it. Though so prominent it is less high than the peaks of the Pīr Panjāl range. In 1816 Captain Hodgson and Lieutenant Herbert determined the difference of height between the two peaks of the Chaur as 460 feet; the higher peak they found to be 1½ miles north of the lower. Atlas Sheet No. 47.

† Between latitude 29° 10′ and 29° 20′, and longitude 82° and 81° 30′.

‡ It is 17,776 feet in longitude 82° 30′, 15,000 in 82° 10′, 12,000 in 81° 30′, and 9,000 in 80° 45′.

§ Map of Kāngra, 1 inch=2 miles; Atlas Sheet No. 47.

the word pīr means "pass"; it has come from the Persian word pīr meaning a faqīr. (*Ancient Geography of Kashmīr*, p. 76). A pass was very frequently selected by a faqīr for his dwelling-place, and thus the name became transferred. Colonel Lorimer heard the Mīr of Hunza use the word pīr for a pass.

The third oblique range leaves the great range at the Sutlej (figure 4, Chart XVI), and forms the water-parting between the Chenāb on one side and the Beās and the Rāvi on the other. It bends towards the Dhaula Dhār range near the source of the Rāvi, and the clash between their flanks has created the mountain knot of Bara Bangahal (Chart XVIII). The Pīr Panjāl is the largest of all the lesser Himālayan ranges, and even at its extremity in Kashmīr it carries many peaks exceeding 15,000 feet.* South of Lahaul a considerable area rises above the snow line and numerous glaciers exist: south of Kashmīr there are no glaciers, but in places snow lies throughout the year.

The North Kashmīr range.

The fourth oblique range branches from the great Himālaya near the Zoji La: it constitutes the water-parting between the Jhelum and Kishanganga, the latter river draining the angle formed by the bifurcation. Its height is greatest near the point of bifurcation, one of its peaks, Harāmukh† (16,890 feet), reaching above the snow-line, but westwards it ramifies and declines. For the first 100 miles of its length it is without a gorge: its width exceeds 30 miles.

The Mahābhārat range.

West of the Singālila ridge an outer parallel range, known as Mahābhārat, traverses the basins of the Kosi and Gandak; it is strongly marked and continues through western Nepāl.‡ Immediately to the east of Singālila, however, no such range is visible, all the lesser ranges having disappeared from the basin of the Tīsta. Further to the east in Bhutān trigonometrical observations have disclosed the existence of an outer range in latitude 27½°.

The peaks of the Mahābhārat range vary from 6,000 to 8,000 feet, dwindling near the left bank of the Kosi to 5,000 feet; throughout its length this range, though serrated like the edge of a saw, offers but few recognisable points to trigonometrical surveyors (see Part III, Chapter 21).

The Mussoorie range.

Between the Ganges and Sutlej there is an outer alignment of hills, of which Sirkanda (9,080 feet), Landour (7,464 feet), Banog (7,433 feet), Badrāj (7,320 feet), and Kasauli (6,322 feet) form prominent points: whether this is a remnant of a more southern range, now almost extinct, or whether it originally formed a

* Map of Kashmīr, 1 inch=2 miles.

† The trigonometrical station of Harāmukh is 16,001 feet high and one mile north-west of the peak.

‡ We can trace it from longitude 86°, latitude 27¼°, through 85°, 27¾° and 83°, 28° to 80½°, 29½°.

flank of the Nāg Tibba range, 10 miles to the north, we are unable even to conjecture: nor can we tell at present, whether this so-called Mussoorie range is a continuation or not of the Mahābhārat range of Nepāl.

The line of mountains we have called the Mussoorie range has barred the exit of the Ganges from the mountains and has forced the Bhāgīrathi, the Alaknanda, and the Navar affluents to unite in rear of it: the junction of the Tons and the Jumna is also due to its presence.

The Rattan Pīr.

South of Kashmīr the outermost range is known as the Rattan Pīr. This range may be the western extremity of a long outer range, pressed near Kashmīr against the Pīr Panjāl range, or it may be an old flank of the Pīr Panjāl range itself and not a separate fold. It is separated from the Pīr Panjāl by the river Punch.

If the Lesser Himālaya had consisted of the oblique ranges only, the mountains might have terminated in the plains of India as diverging and diminishing chains—increasing in number and decreasing in magnitude—like the Hindu Kush in Afghānistān and the Kunlun in China. But one or more outer ranges seem to have been upheaved parallel to the great range and these appear to have pressed back the oblique ranges and to have formed a curvilinear wall stretching almost unbroken for 1,600 miles from the Brahmaputra to the Indus. If the sea were now to flow over the Indo-Gangetic plains, the Himālayan coast would be a long wall without capes or islands.

If we examine Chart XXIII of Part III, or the drainage Charts XXIV to XXXIV, we find that the river basins of the Nepāl Himālaya are disposed symmetrically with regard to the ranges, but that this is not the case in the Punjab Himālaya. The Himālayan basins of the Tīsta, the Kosi, the Gandak and the Karnāli are of simple and symmetrical shapes, such as would be expected to result from rivers flowing down from a great range. But the basins of the Sutlej, the Beās, the Rāvi, the Chenāb and the Jhelum are disposed obliquely with regard to the Himālayan alignments: the axes of these basins are parallel to one another but inclined at an angle to the line of snow peaks.

The symmetry of the Nepālese basins is due to the fact that the Lesser Himālaya ranges in Nepāl are mainly parallel to the great range: the obliquity of the Punjab basins is due to the Lesser Himālaya ranges in the Punjab being mainly oblique.

CHAPTER 11.

THE RANGES THAT SEPARATE THE HIMĀLAYA FROM TIBET.

East of Lake Mānasarowar the boundary range between the two mountain systems of Himālaya and Tibet is the eastern extension of the Ladākh range, shown on the frontispiece chart of Part I as the Nepāl-Tibet watershed.

West of Mānasarowar the boundary range between Himālaya and Tibet is not the Ladākh range at all, but the Zāskār range (Part I, Chapter 4). This complexity is due to the fact that the Great Himālaya range throws off a bifurcation to the north,—its only northerly bifurcation. This bifurcation, known as the Zāskār range, separates the Great Himālaya from the Ladākh range throughout western Tibet (frontispiece Chart, Part I). The "boundary range" between two mountain systems, like the Himālaya and Tibet, is not a purely topographical question; it can however be regarded as a geographical question, because geography recognises the claims to consideration of ethnology and philology. Geography has always to consider the local populations, their outlook, their views and their languages. And as thus we have to make a topographical compromise that will be in harmony with the ethnological and linguistic conditions, we are led to place the eastern Himālayan boundary on the Nepāl-Tibet watershed and the western boundary on the Zāskār range.

The Zāskār range.

The Zāskār range appears to bifurcate from the great Himālayan range near Nampa (see figure 2, Chart XVI), but the exact position of the bifurcation is not known.

The Zāskār range, after leaving the Great Himālaya, culminates in the peak of Kāmet (25,447 feet): near the point of its intersection by the Sutlej the twin peaks of Riwo Phargyul (22,210 feet) rise from it, and in the basin of the Spiti river it carries the peak of Shilla (23,050 feet). Beyond the Indus-Spiti water-parting its peaks rise to 20,000 feet, but further to the north-west they do not exceed 18,000 feet.

Its continuity.—Through the basin of the Indus the Zāskār range can be traced at intervals running in a north-westerly direction parallel to the Great Himālaya (Sheets 5 and 6, Punjab map, 1 inch=8 miles): the region it traverses north-west of Spiti is, however, occupied by complex ramifications of mountains, apparently branching in many directions, and there does not seem to be any definite continuous axis to which all the ridges belong. In some places the Zāskār fold can be clearly seen; in others there appear to be two or more close parallel folds. The continuity of the range as drawn in the frontispiece to Part I has not, we think, been demonstrated.

Sir Alexander Cunningham refers to the Zāskār range in his work on Ladākh and is confident from personal observation of its continuity: "It extends," he writes, "in one unbroken chain through the districts of Chumurti, Rukchu, "and Zāskār to the junction of the Zāskār river, which rushes dark and turbulent "through a vast chasm in the mountains where human foot has never trod. "From this it extends to the junction of the Dras river with the Indus, where "it is again cut through by the Dras river at a narrow gorge called the Wolf's "Leap; but beyond this point it stretches in one unbroken chain to the great "southward sweep of the Indus."

Corrugations.—The parallelism of the upper feeders of the Kāli, in the beds they have carved out for themselves along the eastern portion of the Zāskār range, suggests the possibility of the surface of the range having been originally corrugated (Atlas sheet 66 N. E.) The Dharma, the Lissar and the Kāli itself rise in the Zāskār range and flow in long parallel troughs of the crest-zone at five-mile intervals: their courses are inclined to the direction of the range as though they were the troughs of minor folds obliquely superposed upon the main Zāskār fold.

Transverse ridges.—A great transverse spur protrudes from the Zāskār range at Kāmet into the upper basin of the Alaknanda. For a length of 20 miles its peaks exceed 20,000 feet; its altitude then diminishes to 14,000 feet in 6 miles, and it is not visible south of the Dhauli at Joshīmath.* It is this extraordinary buttress of Kāmet that separates the basins of the Vishnuganga and Dhauli behind the great Himālayan range (Chart XXIV, Part III).

Passes over the Zāskār range.—The Zāskār range, being the water-parting between the Kumaun Himālaya and Tibet, is crossed by a great number of well-known passes: the Lipu Lekh (16,750 feet) is south of the Upper Karnāli basin and near the conjunction of the Zāskār and Great Himālayan ranges. The Manghang Lankpya and Dharma passes are about 18,000 feet, the Untadhura is slightly below 17,500: these passes lead to Tibet out of the basin of the Kāli. The Kingri Bingri (18,300 feet), the Balcha Dhara (17,500 feet), the Shalshal (16,200 feet), the Silikank (18,000 feet) and the Niti (16,500 feet) are all passes across the water-parting between the Dhauli affluent of the Alaknanda and Tibet, and they by no means constitute a complete list. The Māna pass (18,000 feet), called also the Dhungri or Chirbitya, is at the head of the Saraswati affluent of the Alaknanda. (The Saraswati is a feeder of the Vishnuganga. The names of passes are spelt in various ways and much uncertainty prevails). The Muling pass (height unknown) crosses the water-parting between the Bhāgīrathi and Tibet. The Gumrang and Sholarung passes are further west and connect the Himālayan basin of the Sutlej with its basin in Tibet.

* Kumaun and Garhwāl Survey, 1 inch=1 mile. Atlas Sheet No. 65, 1 inch=4 miles.

CHAPTER 12.

THE LADĀKH RANGE AND THE HARAMOSH RIDGE.

Three long ranges stretch across Tibet from west to east; the Ladākh, the Kailās and the Karakorum. The Tibetans have not been aware of their geographical continuity and have applied no names to these long alignments. I have explained in Chapter 3 of Part I that the name Karakorum range has arisen from the famous pass by which this range is crossed in Western Tibet: the name Ladākh Range has been borrowed by geographers from the name of a province, and the name Kailās has been borrowed from the name of a peak.

The name Ladākh Range was first introduced by Godwin-Austen in a map prepared in 1884 by the Royal Geographical Society. The Survey of India has not made use of the map, except that it did accept from it the name "Ladākh Range". In our 1907 edition of this book we applied the name Ladākh Range to the whole range from west to east: our chief reason for so applying it was that we could not obtain any suitable alternative. During the last twenty-five years the original objections to the name have, I think, been growing in strength; and it is reasonable to call the extension of this range east of Lake Mānasarowar by the name "Nepāl-Tibet watershed", which indeed describes it.

Ladākh is only a province of Tibet, but the range to which the name Ladākh has been transferred, stretches outside Ladākh in both directions. On the eastern side it traverses other provinces of Tibet, the natives of which would not comprehend the name of the western province being introduced across their countries. On the north-western side the Ladākh range enters Baltistān, and if the name Ladākh Range were applied to it there the educated Baltis would argue, "this is not Ladākh".

It may be held that the Tibetans are not interested in the question. That is partly true, but they will become interested, and our nomenclature should harmonise with their ideas. Godwin-Austen and Drew both testified to the remarkable intelligence which Tibetans showed in understanding maps.

There is also a scientific objection to extending the name Ladākh Range across Tibet from west to east, and this objection has been slowly emerging from the progress of surveys. The Survey of India in tracing any long range has adopted one method only; it has founded its idea of a range upon "a long succession "of high points following a continuous alignment". I feel obliged to emphasise this point because the Editor of the Geographical Journal informed its readers in 1929 (September, 1929, page 277) that a range was drawn on maps right across Tibet, "because geologists are ready to identify the sequence of rocks "observed in Eastern Tibet with that observed in Ladākh". This statement was without foundation; no geologist has identified rocks in Eastern Tibet with those in Western, and no mountain range has been drawn by the Survey of India

across Tibet for 1,500 miles merely because the same rocks have been found at the two ends of the line. The difficulties over the Tibetan ranges are sufficiently great to deserve the sympathetic co-operation of all geographers. So before I explain the scientific objection to the name Ladākh range, that has recently been emerging, I should like again to say that the Ladākh range has been drawn upon maps because surveyors have discovered throughout its alignment a long succession of high points—rising above the general level of the plateau.

Gaps in the alignment.—When I speak of a "continuous alignment" and of a "succession of high points," geographers will understand that there must be gaps in places. The Great Himālaya is a "continuous alignment" and a "succession of high points," but it has gaps—the gap at the Sutlej being 15 miles wide at 16,000 feet. In the alignment of the Ladākh range there is a gap of 15 miles south-west of Mānasarowar, and another lesser gap at the Sutlej. The largest gap in the Ladākh range is one of 65 miles north of peak Chomo Lhāri: this gap is drained by the Nyang tributary of the Tsangpo. If we note the long unbroken alignment of the Ladākh range for 500 miles behind Nepāl (Part III, Chart XXX) and then observe the reappearance of this same alignment east of the Nyang break behind Bhutān and Assam, we are led to believe that the gap of 65 miles at the Nyang must be due to a decrease in the height of the range and to its local submergence below the 16,000 feet level of the Tibet plateau (see frontispiece chart, Part I).

Although a continuous alignment of high points (except for the gaps at the Sutlej, at Mānasarowar and at the Nyang) has been traced by surveyors from Ladākh to South-eastern Tibet, yet we now realise that the scientific meaning of this range undergoes a complete change near Mānasarowar. East of Mānasarowar the Ladākh range is the Himālayan watershed, west of Mānasarowar it is an independent Tibetan chain and has no connection with the Himālaya. East of Mānasarowar the persistence of this granite range and its remarkable parallelism with the Great Himālaya, fifty miles in rear of the latter, seem to show that it is part of the Himālayan system; west of Mānasarowar it is part of the Tibetan system. The following peaks on the Ladākh range were fixed by Ryder and Wood in 1904 from the Tsangpo Valley:

Name.	Height in feet.	Latitude.	Longitude
		° ′ ″	° ′ ″
Gurla Mandhāta	25,355	30 26 18	81 17 57
W167	20,751	30 13 46	82 8 5
W168	21,007	30 14 25	82 8 38
W156	21,431	30 17 8	82 8 53
W166	21,383	30 9 37	82 9 41
W144	22,032	30 7 26	82 11 17
W145	21,568	30 12 35	82 11 28
W164	20,467	30 1 50	82 19 36

Name.	Height in feet.	Latitude.	Longitude.
		° ′ ″	° ′ ″
W143	20,168	30 0 44	82 21 51
W155	21,754	29 51 0	82 42 16
W162	20,684	29 47 57	82 43 23
W154	22,492	29 45 29	82 45 0
W153	21,477	29 40 32	83 0 3
W161	20.000	29 36 11	83 13 21
W159	20.244	29 30 57	83 21 53
W124	20,560	29 33 51	83 39 5
W89	20,727	28 45 34	85 32 27
W90	21.248	28 46 37	85 32 57
W77	21,169	28 56 58	86 5 12
W48	21,263	28 57 58	87 16 51
R119 Nodzinkangsa	23,600	28 57 2	90 11 1
R121	21,852	28 51 13	90 12 43
R122	21.424	28 50 18	90 13 26
R123	20,456	28 48 25	90 13 33
R289	21,660	28 46 33	91 59 20
R289(a) (Yala Shimbo *of Nain Singh*)	21,768	28 47 46	91 59 20

There is no local name for the Ladākh range east of Mānasarowar. After 1908 Sir Henry Hayden had opportunities of studying the question of a name in Tibet. We have consulted many authorities, Ryder, Wood, Sven Hedin, Cowie, Morshead, Van Manen and others. Their replies have been unanimous that no name for the range exists in Tibet. Near the source of the Tsangpo Sven Hedin found the name Kubi used for the Ladākh range, but it was a local name and not suited for extension. In 1925 I noticed in that great work "The Linguistic "Survey of India" that Sir George Grierson calls the eastern half of the Ladākh range "the Himālayan watershed," but when I consulted him he disclaimed any "geographical" responsibility. In the frontispiece chart of ranges in Part I, I have borrowed Grierson's idea and have given to the eastern half of the range the name "Nepāl-Tibet watershed," and for its western half have retained the name "Ladākh Range". I do not presume to put forward this idea as a solution: it is a suggestion only. The only test of a name is time. I use the expression "Nepāl-Tibet watershed" instead of "Himālayan watershed" because west of the Sutlej the "Himālayan watershed" follows the Great Himālayan range. I feel that the expression "Nepāl-Tibet watershed" may in time convey an interesting idea to the local Tibetans, and that it may represent to them a geographical fact as well as a geographical name.*

I will now trace the geographical features of the Ladākh range. In the 1907 edition of this book on page 93 I wrote in collaboration with the late Sir

* After Chapter 12 had been written a further question had to be considered. Although the Nepāl-Tibet watershed is the watershed between the rivers of Nepāl and the Tsangpo river of Tibet, the political boundary between Nepāl and Tibet is not on the watershed but on the Great Himālayan Range. For this reason the name "Southern Tibet watershed" will be preferable to "Nepāl-Tibet watershed," as has been entered upon the frodtispiece chart of Part I.

Henry Hayden as follows:—"The gap in the range west of Gurla Mandhāta is "difficult to explain, and it is this break in continuity that prevents us from stating "that the Ladākh fold is continuous: from the information at present available it "appears more correct to give one name to the whole range and thereby to imply "continuity, than to give different names to different lengths. Our wonder is that the "ranges of Southern Tibet are as continuous as they are." The decision to adhere to one name was no doubt helped by the inability of experts to suggest alternative names.

The highest point of the whole Ladākh range from west to east is Gurla Mandhāta. (See "*Western Tibet*" by C. A. Sherring, with chapter on Gurla Mandhāta by T. G. Longstaff). East of Gurla the range is strongly developed and is the watershed between Nepāl and Tibet. East of the bifurcation of the Great Himālaya range at Dhaulāgiri the Ladākh range decreases in elevation, and the two ranges then run in striking parallelism, the northern and smaller range being the watershed. Behind the peak of Chomo Lhāri the Ladākh range disappears for a length of sixty-five miles and then re-appears behind Bhutān on the same alignment as before. This temporary disappearance of the Ladākh range makes the Great Himālaya range the Tibet water-parting: west of this gap the Ladākh range is the Nepāl-Tibet watershed and east of the gap it is the Bhutān-Tibet watershed. The breach in the range is drained by the Nyang river, and this Nyang breach is the only place where the drainage of the northern slope of the Great Himālaya flows into the Tsangpo.

Kingdon Ward thinks that the Tibetan peak of Gyala Peri, discovered by Morshead in 1913, may belong geographically to the Ladākh range and such a suggestion is significant (see the concluding paragraphs of Chapter 22, Part III, concerning the Southern Tibet watershed).

Western Half of Ladākh range.—I will now revert to Mānasarowar and will consider the western half of the Ladākh range. As mentioned above there is a break in the Ladākh range at the passage of the Sutlej. But from the Sutlej to Hunza the range is the close companion of the Indus and its relations to this river are extraordinary. The frontispiece chart to Part I shows how the Indus and the Ladākh range are intertwined. For the first 120 miles from its source the Indus flows along the trough north of the Ladākh range and parallel to it; near Thangra, north of Hanle, it bends at right angles, cuts across the range, and forsakes the trough it has been occupying. It now flows for 300 miles along the south flank of the Ladākh range, and then shortly before its junction with the Shyok, passes back across the range to the north side.

The troughs on either side of the Ladākh range are comparatively open and contain no impediments to the flow of the mighty river: the behaviour of the latter in cutting gorges through a granite range in preference to pursuing a straight and simple course is remarkable.

It is a point of scientific interest to note that if we ascribe to the Ladākh range a circular curvature parallel to that of the Great Himālaya, the curvature

of the Nepāl-Tibet watershed (*i.e.*, of the eastern half of the Ladākh range) is continued through western Tibet more closely by the Zāskār range than by the western half of the Ladākh range (see frontispiece to Part I).

North-western termination of the Ladākh range.

We have traced the Ladākh range from the Sutlej to the Indus-Shyok junction. Where is its north-western termination to be located? In the 1907 edition of this book (Part II, page 94) we described the geographical uncertainty as follows :—"In the frontispiece of Part I the third intersection of the range by "the river is drawn at Bunji near the great knee-bend of the Indus: the con-"tinuity of the range has, however, not been proved. It is clear that the Indus "must pass somewhere in this region across the range to the south, but it is not "certain where it does so. The passage may occur a little west of longitude "76°."

In the present edition the frontispiece to Part I shows the geographical uncertainty. In Chart XVII of Part II, I have ventured to suggest that the Ladākh range terminates in the Haramosh ridge, and through the Haramosh ridge joins the Karakorum main range. If we look at the problem from NW. to SE. (instead of from SE. to NW.) the new solution would make the Haramosh ridge and the Ladākh range a bifurcation of the Karakorum. This solution has been suggested partly by the new contoured maps of the Survey of India, and partly by the corresponding problem of the Kailās range. It is an hypothesis only.

The Haramosh ridge has always been a mountain enigma. It is forty miles long and it carries the high peak of Rakaposhi (25,550 feet); yet it has seemed to be unconnected either with the Karakorum or the Ladākh ranges, between which it stands, or with the Kailās range, on the prolongation of which it is situated. On Chart XVII the Haramosh ridge is shown as T. to V. A philosophical traveller may ask, what is the advantage of speculating upon the original alignments and connections of ranges and ridges that have obviously been cut into pieces by rivers and torrents? Such a traveller may perhaps be content to observe the existing ruins without attempting to picture the original edifice. But the surveyor, who has to tabulate thousands of peaks, is pressed by the requirements of nomenclature and classification to distribute his peaks among his ranges, and he has sometimes to trust to his imagination to help him explain isolated mountain fragments. Colonel Tanner, one of the observers of Haramosh, and the artist who painted Rakaposhi, was always insistent on the impossibility of classifying ranges in the field amid a sea of mountain summits, and on the necessity of deducing them from accurate maps.

The name "Ladākh range" should not be extended to the Haramosh ridge. But the latter ridge may in mathematical geography be regarded as a possible connecting "link" between the Ladākh and Karakorum ranges.

CHAPTER 13.

THE KAILĀS RANGE AND THE SASIR RIDGE.

The Kailās range runs parallel to the Ladākh range fifty miles in rear of it. Near Mānasarowar it contains a crowded cluster of peaks, several of which exceed 20,000 feet, and the highest of which is Kailās (22,028 feet). The peak of Kailās is famous in Sanskrit literature as the paradise of Siva. Mr. Sherring writes (*Western Tibet and the British Borderland*, 1906): "The plateau of "Tibet adjacent to the British border varies from 13,000 to 15,000 feet, and "standing clear above the highest part is the mountain range of the Gangri or "Kailās peaks. The peak of Kailās dominates the rest of the ridge by a clear "2,000 feet."

In 1904 Colonel Ryder made a survey of Southern Tibet from Lhāsa to Mānasarowar. His map of the sacred lakes is detailed and reliable; Kailās peak is shown 19 miles north of Mānasarowar, whilst Gurla Mandhāta (on the Ladākh range) is 12 miles south. The lake of Rakas Tal is separated from lake Mānasarowar by a strip of land narrowing in one place to a mile. Near Mānasarowar the Kailās range exhibits its maximum development and the ranges to the south of it expand in sympathy. Within one region are to be found the culminating peaks of four different ranges, Kailās, Gurla Mandhāta, Kāmet and Nanda Devi. A description of the Kailās range running east of Kailās peak and north of the Tsangpo was given in the 1907 edition of this book by Hayden and myself; but it was found to be incorrect by Sven Hedin when he explored the Trans-Himālaya in 1906-08. The trigonometrical data upon which we had drawn the Kailās range east of Kailās peak were the peaks fixed by Colonel Wood. when he was working with Ryder in 1904. Colonel Wood did not explore the Kailās range, but he fixed several high peaks upon it, and as these peaks seemed to arrange themselves upon the map in a continuous linear alignment, we assumed that they were the high points of a range bordering the Tsangpo. We wrote in 1907, "East of Mānasarowar the Kailās range forms generally the northern "rim of the Brahmaputra's trough: it cannot however be called the water-"parting, as it is cut through in places by rivers from the north." Sven Hedin has now pointed out that the peaks observed by Wood were not on a range but on Trans-Himālaya. "Trans-Himālaya," he writes (*Southern Tibet*, Vol. III, page 219), "consists of several different ranges, and some of the rivers stream "between them. The Trans-Himālaya cannot be said to be cut through by "any other river than the Indus." Sven Hedin also takes exception to our description of the watershed of the Raga river as a bifurcation of the Kailās range. It is clear that our conclusions in 1907 had been based upon insufficient topographical data, and the frontispiece chart of Part I has now been corrected accordingly. The eastern extension of the Kailās range and its bifurcation at

the Raga have been omitted from the present edition. In a subsequent chapter I am giving an account of Sven Hedin's explorations in Trans-Himālaya.

The North-west extension of the Kailās range.

In 1907 however we had felt greater doubts concerning the north-west extension of the Kailās range than we did concerning its easterly extension. On the frontispiece chart of 1907 we showed the Kailās range as continuous as far west only as longitude 80° : from 80° to 78° we represented the range by a broken line to indicate hypothesis and uncertainty. In Chapter 12 of this book on the "Ladākh range" I have referred to the impulse that surveyors feel for classifying their peaks into ranges: computers and draftsmen have the same impulse; computers especially dislike unclassified masses of peaks. A "range" means an "arrangement," and the desire to fix peaks into linear arrangements has a scientific basis, for geologists have shown that the elevated zones known as mountain ranges have mostly originated in long folds of the Earth's crust. So in 1907 we gave a broken line to the Kailās range to indicate a belief in its continuity and our inability to represent it.

In order to explain the reasons for the uncertainty in 1907 as to the north-westerly extension of the Kailās range, I will quote Drew's *Jummoo and Kashmīr* 1875. It has been said that Drew is out of date: but geographical facts are never out of date, and Drew had an insight that enabled him to see the essential points of a problem. Drew explained that in longitude 80° (north-east of the Indus and of the Ladākh range) "there is a distinct line of granite mountains, "called by Cunningham the Kailās range, with summits rising to 20,000 feet "and this range ends at Sajum peak (20,018 feet) near the Pangong lake." See Chart XVII: on this chart Sajum is a small distance SW. of the letter K.

If now in 1931 we try to continue Drew's Kailās alignment north-west of Sajum we find no definite range along the Pangong lakes, and then no range till we cross the bend of the Shyok river near longitude 78°. Inside the bend of the Shyok river we meet the Sasir ridge (letter H of Chart XVII) running down like a spur from the Karakorum range. Of this Sasir ridge Drew wrote, "It ends "suddenly at the corner where the Shyok river makes its great bend." Chart XVII illustrates the problem of the Kailās range. The range has been traced from L to K on the chart: the Sasir ridge is strongly developed from G to H; the range is separated from the ridge by the Pangong gap, K to H. On this chart the gap appears to be about 100 miles in length, but Sajum peak is somewhat west of K, and the most reliable map (1925) reduces the length of the gap to 70 miles.

It was the Pangong gap in the Kailās range that led Hayden and myself to regard the Kailās extension across the gap as hypothetical. It is a more difficult gap to bridge than the Noang gap in the Nepāl-Tibet watershed, because the

mountains on either side of it are not on the same alignment (see frontispiece chart of Part I).

Chart XVII shows that the Kailās range is inclined towards the Karakorum range as they cross the meridian of 81°. I am encouraged to make the following quotation from the 1907 edition of this book because I notice that it has been quoted with approval by Sven Hedin and Professor de Margerie. "All the "ranges of Tibet tend to converge at the north-west corner of the plateau, as "though they were trying to escape through the neck of a bottle: once having "passed the neck they separate again, but during the passage they appear to "suffer from extreme compression." As far as we can judge from surface indications the Kailās and Karakorum ranges must come into actual contact about longitude 78°; what happens to them when they collide cannot be discovered without geological investigations. (*Proceedings of the Royal Society, Series A, Vol. 127, 1930, page 711, "Mountains of Tibet"*).

THE SASIR RIDGE.

The Sasir ridge is about 60 miles long from the Sasir pass to its abrupt end at the Shyok; its importance in geography is due to the fact that it carries the Shyok-Nubra group of peaks, the highest of which exceed 25,000 feet. I have a dislike to altering established nomenclature; anyone doing so owes an apology to geographers. As the high group of peaks have been always known as the "Shyok-Nubra watershed" peaks, I was in favour of calling the ridge on which they stand the "Shyok-Nubra watershed". But this latter name has led to confusion; the river Nubra flows between two lines of snow-mountains, both of which are watersheds and both of which are named "Shyok-Nubra watershed". The Shyok river flows down on the north-east side of the Nubra, and then bends round and flows back along the south-west side of the Nubra. The river Nubra is thus environed between two branches of the Shyok. For years there has been confusion; the true Shyok-Nubra watershed is south-west of the Nubra. When in 1865 Montgomerie first fixed the Shyok-Nubra high peaks, it was possible to regard them on a north-east Shyok-Nubra watershed. But we were wrong to continue the name "Shyok-Nubra watershed" all along the Sasir ridge to its southernmost point, because the southern half of this ridge is the watershed between two sections of the Shyok river and is quite independent of the Nubra. As the Sasir ridge from the pass to the Shyok bend is a single mountain entity, I hope that geographers will approve my step in naming it after the pass according to a Central Asian custom.

There is no doubt that a mistake in a name was made in the Survey of India sheet No. 52, scale $\frac{1}{M}$, 1925. An extension of the Kailās range across the empty Pangong gap of 70 miles to the Sasir ridge might have been a justifiable hypothesis: but to end the Kailās range east of Pangong and then to resuscitate it 150 miles further north-west is not possible, when the intervening gap has been given up to

another range cutting across it from the north. This mistake was due to a misunderstanding of the term "Shyok-Nubra watershed". It is thus not possible to quote the Survey sheet 52 as indicating the most probable solution of the Kailās problem.

But there is one modern authority who I think has drawn the Kailās alignment correctly, and that is Mrs. Visser-Hooft. In the chart published in her book, *Among the Karakorum glaciers*, 1926, the Kailās range is taken across the Pangong gap and up the Sasir ridge, until it joins the main Karakorum: this solution shows the Sasir ridge and the Kailās range to be a bifurcation from the main Karakorum, and though such a solution may still be hypothetical it is a reasonable hypothesis.

The Sasir and Haramosh ridges are parallel and similar: they are both about 60 miles long. In Chapter 12, I have suggested that the Haramosh ridge may be a bifurcation from the Karakorum, linking the latter to the Ladākh range. In this chapter I have pointed out that Mrs. Visser-Hooft's drawing has made the Sasir ridge a bifurcating link from the Karakorum to the Kailās range. These ideas are illustrated on Chart XVII, which shows how all the high peaks of Western Tibet can be classified into three ranges: the ranges are inter-related, but we cannot group them into a "Karakorum system", because two of the three ranges extend outside the Karakorum region to Mānasarowar, whilst the Karakorum itself crosses Central Tibet north of Trans-Himālaya. To group them as a "Karakorum system" would be to expand the region Karakorum and make it synonymous with that of Tibet,—to the detriment of both names (see frontispiece chart, Part I).

The geographical difficulty in Tibet has been due to the absence of indigenous names for mountain ranges. Geographers have had to borrow their names from provinces or peaks. It is advisable to introduce only such names as will appeal in time to the people. The name Karakorum came into Tibet from Turkistān; the people of Baltistān like those of Turkistān are Mongolians, and they had accepted the name Karakorum for the pass long before the advent of modern geography. But Baltistān knows nothing of the Sanskrit name Kailās, and the latter is out of place in the Karakorum on the Masherbrum ridge (Sheet 52, 1925).

Whilst then we may consider the idea that the Sasir ridge is the connecting link between the Kailās and Karakorum ranges, the actual name Kailās should not be extended on maps further west than Sajum peak (Pangong), and the local name Sasir will intervene suitably between the names Kailās and Karakorum.

CHAPTER 14.

THE GREAT KARAKORUM RANGE AND THE HINDU KUSH.

The controversy over the *name* "Karakorum" was considered in Chapter 3 of Part 1. In this chapter the controversy over the *alignment* of this range has to be considered. The Survey of India has adopted the view that the Karakorum range traversed Western Tibet on a uniform alignment, from Hunza and peak K^2 to the Depsang heights south of the Depsang basin, and that after being cut across by the upper Shyok river north of Murgo (latitude 35° 10′) it continued on the same alignment north of the Lanak La pass into Central Tibet. (This alignment crosses the meridian of 80° in latitude 34° 15′ approximately, and the meridian of 81° in latitude 34° 5′ approximately, and continues on the same course throughout Tibet.)

Of recent years the hypothesis has been advanced that the Karakorum range does not run through Central Tibet at all, but that it changes its direction in eastern Baltistān through an angle of 30° (south of the Rimo glacier in longitude 77° 30′), and runs down the Sasir ridge to the great bend of the Shyok river (latitude 34° 10′, longitude 78° 10′), and there comes to a sudden end. Controversies of this kind always settle themselves as knowledge progresses: our successors in the year 2000 A. D. will be in no doubt about the Karakorum alignment, and we might leave the question to them with confidence. But as in the meantime geographical names have to be entered upon maps, a summary of the controversy is being given in this chapter in the hope that it may prove of some use in forthcoming years. It is unfortunate that the name Karakorum was entered by an oversight along the Sasir ridge on Survey sheet 52 of 1925: as has been pointed out in Chapter 13, the sheet showed the Kailās range in two pieces separated by a very wide gap of 150 miles, and the Karakorum range was drawn across the Kailās range through the gap. This was clearly an oversight, as two ranges cannot cross one another. The only oversight was in the printing of the names: except that the two names Kailās and Karakorum were entered in wrong positions this sheet is correct. At the time when the sheet was drawn, no controversy had arisen over the Karakorum alignment.

Definitions of terms employed in mountain geography.—In the Himālaya and Tibet we meet so many different types of mountains, that it seems necessary at times to refer to them by different terms. The English language has furnished us with four geographical terms, (1) range, (2) ridge, (3) region and (4) watershed. From a scientific point of view these terms are not sufficient, but we have to make the best use of them. We cannot invent new technical terms, as other branches of science do, because a wide public is interested in geography and they would resent the introduction of technicalities.

If we compare the Himālaya Range with the Siwālik Range, we see that the former is 100 miles wide on one side only, from its crest to its southern foot, whilst the latter is about 25 miles wide, including both its southern and its northern slopes: the height of the Himālaya frequently exceeds 25,000 feet, the height of the Siwāliks is rarely as great as 5,000 feet, yet we apply to these two dissimilar mountains the same term "range". The word "range" clearly means a long linear "arrangement", regardless of height and width. Both the Himālaya and the Siwāliks are chains of enormous length: the one is the high central crest zone of the Himālaya region, the other is the low chain of hills that forms with wonderful uniformity the southern edge of the same region. The Ladākh range differs in character from both the Himālaya range and the Siwāliks: in width and height it is intermediate between the two, but like them it does possess the remarkable characteristic of extreme length.

No change in procedure is now being advocated: the above references to the use of the word "range" have been given to explain to European and Asiatic geographers that long-established custom renders it necessary for the Survey of India to apply the one term "range" to chains of mountains that are very different from one another in appearance.

In the 1907 edition of this book the following passage occurred:—"We "must not confuse *ranges* and *ridges*; *ranges*, however modified by denu- "dation, are features of original structure; *ridges* are the result of "erosion only. *Ranges*, as their name denotes, must possess length, and "an elevated dome or compact mass could not be called a range. But though "length is an essential feature of a true *range*, a long line of mountains is not "necessarily a *range*, for it may have been carved by rain and rivers out of an "older and larger mass." These attempts at definition have met with criticism; surveyors have pointed out that they have no means of ascertaining whether a range is a feature of original structure or a result of erosion. They have also asked why the definitions cannot be based upon topographical features and be made independent of geology. The reason that topographical features are an insufficient guide is that although we can measure the height and the length of a range yet we cannot deduce its width without recourse to geology, and a knowledge of its width is often necessary. Many of our controversies have arisen from treating a range as though it was a line: a watershed is a line, but a range may be many miles wide. We cannot therefore say that a range is "a long line of elevated "rock"; such a definition would make the great wall of China a range: we must include in the definition the geological fact that a range is an uplift of the Earth's crust.

In 1875 Drew referring to the Karakorum and Ladākh ranges called the former a "range" and the latter a "ridge".

In 1873 Dr. F. Stoliczka in his notes on "the Mission to Yārkand" referred to the "Karakorum range", but of our Ladākh range he wrote "the ridge "between the Indus and Shyok running south-east consists of gneiss".

In 1854 the three brothers Schlagintweit were the first Europeans to travel across western Tibet from the plains of India to the plains of Chinese Turkistān. They divided all the mountains into three ranges, the Himālaya, the Karakorum, the Kunlun. They took a broad view and regarded the Ladākh range, the Sasir ridge, and the Aghil range as minor details. They described the Karakorum as the "main range" of High Asia.

If we were to follow these five authorities we should now allot the word "range" to only three ranges of Tibet, namely Himālaya, Karakorum, and Kunlun; but this we cannot do, because we are tied by long-established custom to such names as Pīr Panjāl range, Dhaula Dhār range, Siwālik range. Whilst moreover we may agree with the Schlagintweits that the three primary ranges are the Himālaya, Karakorum and Kunlun, we cannot classify all the mountains of Tibet under these three heads. In Western Tibet the Zāskār, Ladākh and Kailās ranges and the Indus valley intervene between the Karakorum and Himālaya; they belong only to Tibet: in Southern Tibet the large area of Trans-Himālaya also intervenes between the Karakorum and the Himālaya, and cannot be classed with either.

The flat top of a wide range frequently appears to be indented by furrows or trenches running along its summit parallel to its crest-line. The Himālaya has such furrows and they have been called corrugations, the Hindu Kush has a long deep furrow, the Karakorum has longitudinal furrows. They are probably due to the excavation of lines of soft rock by streams: when this occurs the elevated line of rock which borders a furrow is sometimes called a range: it would be advantageous if we could agree to regard these minor lines of elevation as "ridges". Ridges are parts of a range, and are superposed upon ranges; generally longitudinally, occasionally transversely. I would therefore suggest that the following four definitions be accepted:—

(1) A *Range* of mountains is a long zone of elevated rock of considerable width and running in one direction; it is an uplift of the Earth's crust raised by horizontal compression, its surface throughout has been roughly carved into channels, ridges and peaks; its line of direction is generally linear but occasionally curvilinear.

(2) A *Ridge* is a short zone of elevated rock of less importance than a range and is frequently a minor feature of a range.

(3) A mountain *region* is the whole area of land covered by the main mountain range, by its subsidiary ridges, by its spurs, outliers and foot-hills. The expression "Himālaya region" has come spontaneously to mean the whole Himālaya area. The geographical word "region" has the same meaning in the Himālaya as the Indian word "pahār".

(4) A *Watershed* or *divide* is the line which separates two river basins.

A word that has been sometimes used is "system"; it is used in geology, but with a different meaning. The Zāskār "system" in geology denotes a particular system of rocks: it does not correspond with the Zāskār range nor does it define a particular area of elevation. In the dictionary a "system" means "an orderly arrangement according to some common law," but as long as mountains are in orderly ranges and ridges, we do not call them "systems"; it is only when mountain chains begin to run about in apparent disorder that they are called a "system".

The broad range of the Hindu Kush has become divided by rivers into two parallel ranges, both of which are long and important features. In this case geographers in the field have named the two component ranges, the Northern Hindu Kush range and the Southern Hindu Kush range; and when they refer to the whole Hindu Kush embracing both the component ranges, they call it the "main Hindu Kush range". The same course has been adopted in the case of the two Kunlun ranges.

The Secretary of the Asiatic Society of Bengal, who is in touch with Calcutta opinion, has written, "The plan introduced by Burrard and Hayden's Himālayan "Geography in 1907 of naming the main range of the Himālaya the Great "Himālayan range has proved successful. It is self-explanatory, and it embraces "all major and minor features". This opinion from the Asiatic Society of Bengal has encouraged us to make use of the name Great Karakorum Range. Under this name we include the central Karakorum, the Karakorum watershed, the Baltoro, Siachen and other glaciers, the Shaksgam trough, the Aghil range and the Masherbrum ridge.

The Alignment.

Since Montgomerie made his surveys of Western Tibet in 1855-65, the Survey of India's opinion that the alignment of the Karakorum range must be continued across Depsang into Central Tibet has been founded upon the broad geographical principle that a continuity of alignment in one direction is a property of high ranges. Alignments may adopt a gentle curvature, but they do not exhibit angular bends. The theory accepted by the Survey was thus based on the fact that the Karakorum range was trending towards the centre of the Tibet plateau. The plateau had not been explored, and had not been open to European exploration. In the chart of ranges published in Mr. and Mrs. Visser's recent book on the Karakorum glaciers, the Karakorum alignment is drawn correctly across Central Tibet.

We have now to consider the modern theory that the Karakorum alignment does not traverse Central Tibet at all, but that it bends in Baltistān to the south-east and follows the Sasir ridge along the so-called Shyok-Nubra watershed (see Chart XVII).

The first occasion on which the Sasir ridge was adopted by a high authority as the Karakorum continuation was during the Duke of the Abruzzi's exploration in 1909. (*Karakorum and Western Himālaya,* by Dr. Filippi, 1912. The spelling of Sasir is taken from Survey sheet 52 of 1925). It was then advanced as a scientific theory: but since 1927 important changes in nomenclature have been based upon it (*Geographical Journal,* April 1927, September 1929, August 1930), as though the question were no longer open to doubt.

In April 1927 the Geographical Journal published a chart in which the Sasir Ridge was assumed to be the Karakorum extension and to give the true alignment to the Karakorum range. (Subsequently published in the Shaksgam report Survey of India, 1928, and in the Geographical Journal for September 1929 and for January 1930; also in a paper published in the Proceedings of the Royal Society, Series A., Vol. 127 of 1930). This chart showed eight parallel ranges running across the old Karakorum alignment, and across the Karakorum watershed. The eight ranges were not in accord with the topography shown on Survey maps and if produced either to the NW. or to the SE. they departed further and further from the old Karakorum alignment. No one of these eight ranges was the Central Asian divide: the ranges were drawn across the true divide: the divide had no representation upon the chart. The Karakorum pass which is obviously on the divide was placed not on any one of the ranges but in a valley between two ranges.

The question for consideration now is whether the main Karakorum alignment (shown as A to C on Chart XVII) is continued across Depsang from D to E or whether it follows the Sasir ridge from G to H. The frontispiece chart of Part I gives a wider view than Chart XVII.

The evidence that has been brought to bear upon the controversy may be summarised under six heads as follows:—

1. The strike of the strata.
2. The drainage.
3. The width of the range.
4. Heights.
5. Maintenance of one direction.
6. Length and continuity of the alignment.

(*1*) *Strike of the strata.*—This furnishes no indication of the line of elevation. A fold of the crust may be upraised by horizontal compression along a line that does not correspond with the direction of strike. Stoliczka of the Geological Survey, who died in Ladākh, made geological surveys of the Changchenmo-Karakorum region: he referred to the "Karakorum range", but never suggested that it followed the Sasir ridge. (*Records, Geological Survey of India,* Vol VII.)

In the account of the Abruzzi expedition Dr. Novarese had stated that "the Karakorum consists of a series of chains parallel to each other and to the "geological zones." These geological zones are inclined to the main Karakorum alignment at an angle of 30°, and they follow the Sasir alignment. Mr. R. D. Oldham of the Geological Survey of India has expressed his disagreement with Dr. Novarese, and has stated his belief that the peaks of K^2, Gasherbrum and Teram Kangri may all be on one range and may belong to the group of ranges crossed by the Karakorum pass.

(2) *The Drainage.*—It has been argued by advocates of the Sasir ridge alignment that the depression in the main Karakorum range at the divide between the Shaksgam and Nubra rivers is a proof that this range is not continuous, and that it does not trend across Depsang towards Central Tibet. The Shaksgam-Nubra depression is held to prove that there are two ranges inclined at an angle to the main alignment, one from Teram Kangri running on the north-east side of the Nubra river along the Sasir ridge and the other from K^2 following a parallel course on the south-west side of the Nubra river. This hypothesis recalls the early history of Himālayan geography, when explorers tried to deduce the configuration of the Himālaya range from the courses of the rivers. In 1807 Captains Raper and Webb explored the source of the Ganges, and reported that they had reached the source without crossing the Himālayan range. They had not realised the possibility that the gorge which they had followed had been cut by the river through the great range. On the Karakorum the Nubra is cutting a gorge like the Ganges has done. By means of its gorge the Ganges was able to capture the local Tibetan drainage, and if the Nubra is allowed time it will possibly capture the Shaksgam drainage.

In 1849 a mistake similar to that of Raper and Webb was made by Hodgson in Nepāl: he argued that the great Himālayan peaks could not be on the same range, because they were separated by river gorges. The Hodgson mistake has become historic. Sir Clements Markham summed up the Hodgson controversy in 1871 by saying that "a range does not cease to be a range if it has been "cut through by a river." Lines of elevation do not follow the courses of rivers.

(3) *Width of the Karakorum range.*—When a range appears to separate into two ranges the relative widths of the two component parts are useful data when we have to decide which is the main range. The width of the southern slope of the Karakorum range from the Gasherbrum crest-line to the bed of the Shyok is about 50 miles, and if we assume that the crest-line is over the centre of the range the width of the northern slope of the Karakorum will be 50 miles also (that is, to the bed of the Raskam-Yārkand river); the total width of the Karakorum range at an altitude of 12,000 feet will thus be about 100 miles. The width of the Sasir ridge at the Sasir pass is 21 miles, and in its widest part is only 30 miles. Thus the evidence deduced from the relative widths leads to the

belief that the narrow Sasir ridge cannot be the continuation of the great Karakorum range.

(*4*) *Relative heights.*—The following is the evidence furnished by heights of observed peaks. The Sasir ridge has a high group of peaks which exceed 25,000 feet; the Depsang alignment carries peaks of 21,000 feet and a few exceeding 22,500 feet. West of the Shyok gorge a peak of 24,660 feet marks the Depsang alignment, and east of the gorge is a peak of 22,730 feet, and another of 21,900 feet further east. If these relative heights were our only available evidence we might be tempted to decide in favour of the Sasir ridge alignment, but a solitary height or two is not conclusive evidence. Rakaposhi and Gurla Mandhāta which are both higher than the Sasir peaks are on no great range. For 130 miles from the Nun Kun peaks to Nanga Parbat, the Great Himālaya Range does not show a peak of 20,000 feet. The Depsang alignment of the Karakorum is thus considerably higher than this part of the Great Himālaya.

If our predecessors had relied upon solitary high peaks, they would have been led astray in the case of the Himālayan alignment. In the Gangetic basin twenty miles in rear of the Himālayan peaks of Badrīnāth and Kedārnāth stands the Zāskār peak of Kāmet, which is 2,500 feet higher than either, but the Zāskār range is not the main range. Near the Sutlej the Zāskār range carries the high peaks of Shilla and Riwo Phargyul, which are 5,000 feet higher than any peak on the corresponding section of the Himālaya, but the Himālaya is the main range, not the Zāskār (see Charts XXIV and XXXI). It would therefore be unwise to base the Karakorum alignment upon a single group of peaks, even if they do rise above 25,000 feet.

(*5*) *Maintenance of one direction.*—In Chart XVII the crest-zone of high peaks (above 25,000 feet) follows a direct alignment from A to C through Baltistān for 160 miles; and if we continue this alignment on our maps it will cross Depsang at D and pass through towards Central Tibet. If however we decide to continue the AC alignment down the Sasir ridge from G to H, we have to bend it at G towards the south, through an angle of 30 degrees.

The Himālayan ranges show gentle curves, but they show no sudden bend through 30 degrees: this change in direction is a distinct objection to the Sasir alignment.

(*6*) *Length and continuity of the alignment.*—The Sasir alignment ends suddenly at H (Chart XVII) at the river Shyok,—only 60 miles from its connection at G with the Karakorum. The advocates of the Sasir alignment have not mentioned this fact, nor considered its bearing upon the controversy. On the other hand Sven Hedin has shown that a great range continues from Depsang D to E and across Tibet; this range is a continuation of the same Karakorum alignment AC that runs through Baltistān for 160 miles. The evidence discovered by Sven Hedin is very important and indeed conclusive. Continuity of alignment is the most important evidence of all (Chart LXXXIX, Vol. VII, Sven Hedin's *Southern Tibet*).

In August 1906 Sven Hedin crossed the Karakorum range near the point E, 60 miles east of the Lanak La. In his book "*Trans-Himalaya*", Vol. I, p. 79, he refers to this section of the Karakorum as "the colossal ridge of the Karakorum "mountains running right through Tibet." Still further east he again crossed the "crest of the Karakorum," (Chapter VII). A year later in December 1907 he followed the upper Shyok river through the Murgo defile into Depsang; avoiding the Karakorum pass he ascended the Depsang Valley eastward, "so as to "arrive at the main crest of the Karakorum range." (Vol. II, p. 243.)

As we therefore possess so much evidence in favour of the Tibetan extension of the Karakorum range, it is advisable to consider how to name this extension, as it traverses Tibet. In Afghānistān and Chitrāl the western section of the range is known as the Hindu Kush: in Hunza and Baltistān it has been given the Turki name Karakorum. The Survey of India had always looked forward to discovering a Tibetan name in Tibet for the eastern section: but Sven Hedin found no Tibetan name. He thinks that the Karakorum may merge in Eastern Tibet into the Tang La range, but this connection has not been proved. (The Tang La was crossed by Prejevalsky and Kishen Singh: it is the waterparting between the Yangtse and Salween, and was said by Kishen Singh to possess several snow peaks.) In the absence of any Tibetan name, Sven Hedin has continued the name Karakorum along the range into Central Tibet, and we cannot do better than follow his example. He has always endeavoured to introduce Tibetan names wherever they were in general or local use; he has shown that the Aling Kangri peak is on a Tibetan range south of the Karakorum (see frontispiece chart, Part I) and he has given the old Tibetan name Aling Kangri to this range. There is no great objection to extending the name Karakorum into Central Tibet: the population is scanty and nomadic and the Turki and Tibetan languages both belong to the Mongolian family. Many ranges in Northern Tibet have Turki names. It is to be hoped that geographers will approve of the extension of the name Karakorum. Such a step will necessitate one important change: we must not in future reports speak of Depsang and the Rimo glacier as the Eastern Karakorum.

The Component Parts of the Karakorum Range.—In the 7th Volume of his work on Southern Tibet Sven Hedin has given a comprehensive definition of the expression "Karakorum Range": "the Karakorum Range", he wrote, "is the "backbone of High Asia." If we accept this broad view, our disagreements about the alignment and the watershed will disappear.

At the beginning of this chapter I endeavoured to define the words range and ridge. A range was assumed to be a long important line of elevated rock; a ridge a short line of elevated rock of minor importance: the difference between them cannot be numerically defined and has to be left to the judgment of geographers. Before we can decide which ridges are component parts of the Karakorum range, we have to take into consideration the latter's width, which we have already assumed to be about 100 miles.

The width of the southern half of the Himālaya from its snow-crest to the plains of India is about 90 miles in Nepāl, 100 miles in Garhwāl, 110 miles in the Punjab hill states: whilst however we can see the Himālaya rising from the low plains to the snows, the lower half of the Karakorum is buried below the plateau and is hidden from our view. If we take the long Shyok Valley west of its junction with the Nubra as the visible foot of the Karakorum crustal uplift, the width of the southern half of this uplift from foot to crest is 50 miles. The Shyok Valley is over 12,000 feet above sea-level, and if the Karakorum were visible like the Himālaya down almost to sea-level the width of its southern half might be 100 miles, like that of the Himālaya. If on the other hand we could flood the Himālaya by the sea up to a depth of 12,000 feet, its visible width would not exceed that of the Karakorum.

It is then reasonable to assume that the width of the southern half of the Karakorum fold is 50 miles at 12,000 feet, and also to assume a similar width for the northern half. The total width of the "Karakorum Region" in Baltistān will then be 100 miles at 12,000 feet, and it will extend from the Shyok Valley on the south to the Raskam-Yārkand Valley on the north. South of the Shyok Valley we meet with the Ladākh range; north of the Raskam Valley we are in the Kunlun region. The Karakorum Range is the high zone that forms the central belt of the Karakorum Region.

When we come to consider the component parts of this range, it is necessary to bear in mind that when a fold of the earth's surface is uplifted by crustal compression, it is composed of all kinds of rock, some hard and durable, some soft and friable. When an engineer erects a building of stone, he selects his material, but nature makes no selection; when an engineer is making a road across the Himālaya, he occasionally has to blast a wall of hard solid rock, and he occasionally has to cross a mountain that is perpetually sliding and blocking his excavations. It is therefore not surprising that the whole Karakorum region after centuries of exposure to the weather is covered with rock excrescences and rock hollows. As moreover the uplift of the range may have been a gradual process extending over long ages, the irregularities caused by weathering may have been accentuated.

The principal ridges on the southern side of the Karakorum crest are the Haramosh, the Masherbrum, and the Sasir. In Chapters 12 and 13, it has been suggested that the Haramosh ridge is a link connecting the Karakorum with the Ladākh range and that the Sasir ridge is the connecting link with the Kailās range, both these ridges having been upraised by the collision of the Ladākh and Kailās ranges with the Karakorum. The Sasir ridge has the appearance of being a high massive spur of the Karakorum.

The Masherbrum ridge carries the high Masherbrum peaks, and it runs parallel to the main Karakorum crest-line, 20 miles south of the latter, and continues as a marked ridge for about 60 miles: it is separated from the main Kara-

korum crest by the deep trough of the Baltoro glacier. Dr. Arthur Neve thought that the Masherbrum ridge was a second Karakorum range running parallel to the main range. But the most modern maps do not support this theory. The Great Karakorum range has a wide crest zone furrowed by the Baltoro: the Masherbrum ridge is a secondary crest of this wide range: it is a secondary feature of the great uplift. Its length is short, for it conjoins with the main Karakorum crest at the Baltoro-Siachen divide. (It is possible to draw one range from Gasherbrum and Teram Kangri along the Karakorum watershed, and a second range from Masherbrum across the Depsang gorge at Murgo: but this analysis destroys the unity of the great range which is the dominating feature of Western Tibet; see Chapter 16.)

The principal ridges on the northern side of the Karakorum crest are the Aghil ridge, the Karakorum watershed, and the Hunza watershed. These all appear to be minor features of the great uplift. In the 1907 edition of this book we took an exaggerated view of the importance of the Aghil ridge: owing to our mistake in tracing the Karakorum alignment too far south in its passage across Tibet, we were led to attribute some high peaks discovered by Deasy in 1896 to the Aghil continuation: but Deasy's peaks belong to the Karakorum. We made it clear however in 1907 that our Aghil alignment was conjectural. Filippi's and Wood's surveys in 1904 north of the Karakorum showed that there was no Aghil range. Mason's survey of the Shaksgam Valley in 1926 showed that there is an Aghil ridge about 100 miles long dividing the drainage of the Shaksgam and Raskam rivers. It is only a minor surface feature when compared with such mighty ranges as the Karakorum and Kunlun.

The Survey of India has looked upon the Karakorum watershed north of the Depsang basin as a component part of the Karakorum range. In 1820 Moorcroft and in 1854 Cunningham and Schlagintweit were justified in stating that the Karakorum Range was the Central Asian Watershed. In recent times their view has been disputed, but if we take a broad view we can have little doubt that *the watershed is on the Karakorum.* The Survey has never been able to survey the eastern limits of the Depsang basin beyond the Ladākh border: but Sven Hedin's explorations have led him to believe that the watershed range is a bifurcation from the Karakorum at the Rimo glacier, and that it continues in close parallelism to the main Karakorum through Tibet. The Karakorum watershed is twenty miles in rear of the Karakorum crest-line in Depsang. It is 36 miles in rear of the Karakorum crest-line in Hunza. A recession of the watershed by twenty miles is nothing extraordinary in the Himālaya. At the source of the Jadhganga branch of the Ganges, the Jelukhaga pass over the Zāskār range is eighteen miles in rear of the Zāskār crest-line.

The Bhote Kosi and Dūdh Kosi rivers (Chart XXVIII) rise in the Great Himālaya range but north of its axis, the former at the Thanglang pass (18,460 feet), the latter at the Pangula (20,000 feet). These passes are not situated on the

axis of the Great Himālaya, but thirty or forty miles in rear of it. The rivers have cut through the axis and crest and the passes cross only the northern flank of the range. Similarly, the passes into Tibet from the Tīsta basin, the Koru (16,900 feet), the Ṇaku (18,186 feet), the Dongkya (18,100 feet), are over the northern flank of the Great Himālaya, but not over the axis. The peculiarity which differentiates the Karakorum pass from the Himālayan passes just mentioned is that it has on the south side a longitudinal trough, but this may have been carved out of soft rock by a glacier or stream, and is a minor feature.

In Part I of this book I explained that geographers in writing of a complicated mountain range are obliged at times to take a synthetic view and to regard the range as one great whole, whilst at other times they have to take an analytic view and discuss various parts of the range separately. These two views are not antagonistic: Sven Hedin speaks of the "Karakorum range" as the backbone of High Asia: this is a synthetic view. He also speaks of the "Karakorum "watershed range", and this is an analytic view. It is difficult to avoid using the word "range" to denote at times the whole wide elevated fold, and to denote at other times a long subsidiary line of elevation: but we can always make our meaning clear by adding an explanatory word, the "main range", or the "water-"shed range." In the Hindu Kush, for example, we are at times obliged to refer to its two parallel walls as the "Northern Hindu Kush" and the "Southern "Hindu Kush". At other times we class both walls together under the title, the "Main Hindu Kush Range". The Karakorum watershed is to the main range what a man's arm is to his body, and the pass represents his hand: the arm and the hand are parts of the body. If the Tibet plateau were removed and we could see the Karakorum range standing upon sea-level, the Karakorum watershed would be standing aloft and would obviously look as if it belonged to the range. It would, in fact, appear like the Masherbrum ridge, which is the same distance south of the main Karakorum crest-line as the Karakorum watershed ridge is north of the Depsang crest. The Depsang basin lying between the Karakorum watershed and the crest-line, if filled by a glacier like the Baltoro, would appear part of the Karakorum. The Baltoro trough, the Shaksgam trough and the Depsang basin are hollowed corrugations upon the great range, such as are seen in the Kumaun Himālaya, and also in the Nepāl Himālaya between Mount Everest and Chamlang.

The Hunza watershed is also a minor feature of the Karakorum on the latter's northern flank: it corresponds to the Karakorum watershed in Depsang: the connection between these two watersheds north of the main Karakorum has been destroyed by the Shaksgam drainage. The most probable explanation of these two watersheds protruding north of the main Karakorum alignment is that they are both relics of the original northern flank of the great Karakorum fold, and that the intervening parts of the northern flank have all been destroyed by the drainage. The watershed in Hunza has receded behind the Karakorum crest-

line to a greater extent than in Depsang. As this recession progresses and the watershed ridges move northwards down the flank of the fold, their heights will gradually decline. This has already occurred to a certain extent: the Hunza watershed, which is at a greater distance now behind the main crest than the Depsang watershed, is not so high as the latter: its peaks and its passes are on the average 2,000 feet lower than those of the Depsang watershed.

Eastern Extension of the Karakorum Range.—Sven Hedin's explorations of the Tibetan continuation of the Karakorum range have shown that two ranges more or less parallel trend side by side through Tibet. Sven Hedin names them the Northern Karakorum and the Central Karakorum (*Southern Tibet*, Vol. VII, Chapter LXII, Plate LXXXIX, page 586). He was not able to prove that these two ranges were both continuous: he discovered breaks, especially in the Central Karakorum. He also found short lateral ridges appearing on the northern flank of his Northern and on the southern flank of his Central Karakorum. One important fact seems to stand out clearly, namely that a great and wide Karakorum fold stretches across Central Tibet as far east as longitude 85°. This fold seems to be made up of two ranges, like the two walls of the Hindu Kush: but the close relationship of these two ranges to one another, and their partnership in one fold, seem to be more clearly in evidence than their separation into different alignments.

Notes on the Shaksgam Valley, by Major K. Mason, who explored it in 1926.

The Shaksgam Valley, throughout its length, does not conform to the strike of the rocks of the ranges on either side of it, nor is it parallel to the granite-gneiss nuclei of the Karakorum. It may be divided into four sections:—

(1) From its source for a distance of about 12 miles, the Shaksgam valley is parallel to the strike and its bed falls from 17,900 feet to 16,200 feet, a fall of about 140 feet per mile.

(2) From this point its course is slightly north of west, and the river flows in a broad valley. In this second section the bed falls from 16,200 feet to about 14,600 feet in 24 miles, or only 66 feet per mile. During its course here the Shaksgam is fed by two large glaciers, the Kyagar and the Singye.

(3) The third section contains the north-west course of the river, and is parallel to the line of the hard limestones of the Gasherbrums and of the ridges between the Gasherbrum, the Urdok, the Staghar, the Singye and the Kyagar glaciers. In this section the valley-bed falls from about 14,600 feet to about 12,200 feet in 25 miles, or about 96 feet per mile.

(4) In the fourth section the Shaksgam valley while bending westwards cuts across the strike diagonally, until it reaches the junction of the Sarpo Laggo. The fall in this section is again reduced to about 50 feet per mile as the river cuts down its bed with difficulty in the harder limestones. Above this junction the Shaksgam is narrow, with hard limestone cliffs on either side; below the junction it suddenly widens out, and changes direction to the north-west.

The Hindu Kush.

Trigonometrical observations and topographical surveys have led us to believe that the Hindu Kush is the western continuation of the Great Karakorum Range of Balti, and that it is made up of two distinct parallel ranges. The Emperor Bābar in his memoirs and the Afghāns of the present day have taken a broad view and have regarded both ranges as component parts of the Hindu Kush; topographical surveyors have discovered (1) a main crest-line standing in front and cut through by rivers, similar to the Karakorum in Depsang and Hunza, and (2) a watershed range behind, similar to that in Depsang and Hunza. At the Darkot pass the watershed range of the Hindu Kush is 11 miles in rear of the main range.

The Great Karakorum Range of Balti passes north of the Hispar glacier; it then curves round north of Hunza fort and south of the Batura glacier, carrying peaks of 24,000 feet and 22,000 feet as far west as longitude 74° 20′ (latitude 36° 40′). Here there is a gap excavated by the Karambar river, but the same range-alignment is continued west of the Karambar gap by a peak of 24,091 feet. Until 1927 our ideas of the Hindu Kush had been based upon surveys made during the Afghān wars and on boundary commissions; the recent survey of Chitrāl has not altogether confirmed the idea of two parallel Hindu Kush ranges. Colonel Lewis regards them as one range. The Chitrāl Survey has given greater definition and prominence to the Hindu Rāj range, which is a branch of the Hindu Kush; see Chapter 25 of Part III.

Westwards from Tirich Mīr the Hindu Kush continually throws off minor branches and declines in height; in longitude 68½° its peaks rise above 16,000 feet, in 66° they rise to 12,000 and in 63° they hardly reach 10,000. Except for the passage of rivers, its alignment though curved is continuous for 150 miles, from the range we call Karakorum in Hunza, to the range which the Afghāns call Hindu Kush.

Range curvature.—The Great Himālayan Range has a curved alignment; and at the place where the curvature is sharpest, the range has suffered greatly from erosion. It is true that the Sutlej breaks through here, but from comparisons with other Himālayan gorges it seems probable that the Sutlej was not the main cause of the destruction but that it broke through because at this point it found a very weak spot in the range. The Karakorum-Hindu Kush range has in Hunza-Chitrāl a sharper curvature than the Himālaya, and this must have strained and cracked the rocks out of which it is built. The Himālaya curvature is convex to the south, and thus turns its back upon the rain-bearing

winds. The Hindu Kush curvature is concave to the south, and opens its arms to these winds. The Hindu Kush thus furnishes its rivers with a converging basin, which has enabled them to cut the range into fragments.

The Tirich Mīr buttress.—North from Tirich Mīr a perpendicular buttress projects from the Hindu Kush and deflects the Oxus to the north; it resembles the buttress of Kāmet, and in the same way as the latter issues from the culminating point of the Zāskār range, so does the former protrude from the Hindu Kush at the place of its greatest vertical expansion.

Passes over the Hindu Kush.—The beds of the great rivers that pierce the Southern Hindu Kush range provide thoroughfares, and the number of well-known passes over this range is consequently not large. The Darkot (15,000 feet) is perhaps the most important; it crosses the range opposite to the Baroghil (12,460 feet) and Shawitakh (12,560 feet) passes of the Northern Hindu Kush.

The Northern Hindu Kush is pierced by a few torrential streams, but by no great river. It is crossed by an extraordinary number of passes: west of longitude 67° there are the Sharak Kushta, the Barkak and several others between 10,000 and 11,000 feet. Further east there are the Irak (13,500 feet), the Chahardar (13,900 feet), crossed by the Afghān Boundary Commission in 1886, the Kaoshan (14,340 feet), crossed by Alexander the Great, and the Khawak (11,640 feet), a great trade route. Near the trijunction of the basins of the Indus, Oxus and Tārīm, there are numerous passes which average in height about 16,000 feet, two of them however being low, namely the Baroghil (12,460 feet) and the Shawitakh (12,560).

The length of the Karakorum-Hindu Kush range from Tirich Mīr to Central Tibet is 1000 miles, the length of the great Himālaya range from Nanga Parbat to Namcha Barwa is 1500 miles. The Karakorum-Hindu Kush range follows a curved alignment concave to the south (frontispiece chart, Part I), the Great Himālaya follows a curved alignment concave to the north. The curvature of the Himālaya is very conspicuous upon maps because the mountain range borders the flat low plains of Northern India; and it has attracted the attention and interest of geologists. But the curvature of the Karakorum-Hindu Kush range is hidden upon maps, amongst surrounding mountains, and it has received no attention outside geography.

(The recent survey of Chitrāl has brought to light certain errors in the original survey of the Hindu Kush; see Chapter 25 of Part III.)

CHAPTER 15.

TRANS-HIMĀLAYA.

The mountainous area of Tibet now known as Trans-Himālaya was discovered in 1906 by Sven Hedin, and was explored by him in the years 1906-1908. He made seven independent crossings of the whole Trans-Himālaya region in different parts. His interesting account of these explorations is to be found in Volume III of *Southern Tibet*. In its central part Trans-Himālaya is 140 miles wide from south to north and extends from latitude 29° to 31°; it is about 600 miles long from west to east, and extends from longitude 81° to 91°.

The eastern and western sections of the Great Himālaya range are both bent northwards by the Himālayan curvature, and these two curved arms embrace Southern Tibet between them. The two lesser ranges of Southern Tibet that are situated in rear of the Himālaya are curved in approximate parallelism to the latter. The centre of curvature of all these three ranges is near latitude 39° 30′ and longitude 87° 50′; but this geometrical centre is only a theoretical point and has no scientific significance.

The southern boundary of Trans-Himālaya conforms to the Himālayan curvature, and from Lake Pangong to Lake Tengri Nor is in the shape of a loop; the northern boundary is approximately straight from Pangong to Tengri Nor. The Himālayan curvature is not repeated in the long Aling Kangri range north of Trans-Himālaya. Trans-Himālaya appears to be an extensive mountainous area that has suffered from horizontal compression not only in a meridional direction, but also from west to east owing to the embrace of the Himālayan arms.

Until Sven Hedin explored Trans-Himālaya the region had been believed to be a level plateau traversed from west to east by one or more linear ranges. In 1874 the Survey explorer Pandit Nain Singh followed a long straight trough containing a continuous series of lakes, and he described it as so level that he could have driven a bullock cart along it; this trough was north of Trans-Himālaya. Starting from Ladākh, Nain Singh passed to the north of the Aling Kangri peak (24,000 feet) and for more than 800 miles he travelled nearly due east, and saw to his south an almost continuous range of snow-mountains. This range is shown on Sven Hedin's orographical map (LXXXIX, Vol. VII) as the chain of Aling Kangri; it is situated immediately north of Trans-Himālaya. Its alignment as represented by Sven Hedin exhibits no curvature towards the south (frontispiece chart, Part I).

In the following table the most important features of Trans-Himālaya are compared with those of the Himālaya.

—	Himālaya.	Trans-Himālaya.
Length . . .	1,500 miles	600 miles.
Width . . .	In Nepāl from watershed to plains 140 miles; In Punjab from crest-line to plains 110 miles.	140 miles in the centre, narrowing to 20 miles at eastern and western ends.
Height of visible foot	Plains of India 1,000 feet . .	Plateau of Tibet 16,000 feet.
Heights . . .	Peaks considerably higher . .	Passes generally higher.
General appearance .	One long high central crest-line dominates the region.	No marked crest-line or central alignment.
Drainage . .	The whole region is divided into drainage basins by transverse rivers, and these basins have determined the political and racial boundaries.	No division by rivers, drainage flows into small irregular lakes; a few minor streams feed the Tsangpo.
Shape . . .	A long zone of uniform width .	Wide in the centre, tapering towards east and west.

The two governing features of the Himālaya have been (1) its long dominating crest-line, and (2) its separation into transverse drainage units by great rivers. These features are absent from Trans-Himālaya, and we can see no orderly arrangement either in lines of elevation or in courses of drainage.

A popular account of Sven Hedin's explorations was published in his book entitled *Trans-Himālaya* in 3 volumes: he left Ladākh for Trans-Himālaya in June 1906 and returned to India in August 1908. The following quotations are made to explain the impressions which he received of the region now called Trans-Himālaya:—

(1) "The mountain ranges are ill-defined and confusing. It is a desolate "chaos of mountains."

(2) "On the north side of Trans-Himālaya the predominating lines are "undulating: on the south side the valleys are boldly excavated "in rock masses." (The monsoon precipitation is more abundant on the south side.)

(3) "On the eastern flank of Targo-Gangri 5 glaciers are deeply embedded. "Targo-Gangri is a lofty isolated massive, majestic and dominating."

(4) "January, 1908, 40 degrees below zero; crossed the Karakorum range "south-east of Arport Tso" (lat. 34°, long. 82°).

(5) "Trans-Himālaya is the watershed between the Indian Ocean on the "south and the enclosed drainage depression on the north."

(6) "A singular country; the mountains do not form continuous chains, but "rise in rolls of weathering products or steep humps of solid rock, "apparently without any order."

(7) "Trans-Himālaya is a host of different ranges, a folded system of the "Earth's crust, surpassed in loftiness by the Himālayas, but their "equal in massiveness and importance."

(8) "In the area of the Central Trans-Himālaya the crust wrinkles are bent, "turned and pressed together, as if they had been exposed to lateral "stresses from west and east as well as from the north."

The high peak of Aling Kangri was discovered by Nain Singh; it has figured largely in Tibetan geography. For years it was thought to mark the easterly prolongation of the Great Karakorum range, but it is now believed to be considerably south of the Karakorum alignment. Sven Hedin refers to it thus:—

"Aling Kangri is a snow-clad mountain group, the relation of which to "Trans-Himālaya has not yet been ascertained."

In Trans-Himālaya Sven Hedin crossed a great number of passes averaging in height 17,500 feet, a few exceeding 18,000, and one (the Ding La) 19,308 feet.

Although the area of Trans-Himālaya is a confused and chaotic mass of disorderly ridges, it is bounded by 3 definite ranges:—

(1) On the south-west by the Kailās range; a granite range about 20 miles broad.

(2) On the south-east by the Nyenchen-tang-lha, a strongly marked range higher and wider than the Kailās.

(3) On the north by the Aling Kangri range.

The following peaks on the Nyenchen-tang-lha were fixed by Colonel Ryder in 1904:

Name.	Height in feet.	Latitude. ° ′ ″	Longitude. ° ′ ″
R^{210}	22,950	29 54 7	90 2 3
R^{291}	20,207	29 51 26	90 13 25
R^{216}	21,694	30 18 9	90 29 7
R^{212}	20,456	29 57 7	90 32 46
R^{217}	23,255	30 22 17	90 35 19
R^{219}	20,366	30 27 37	90 41 41
R^{222} or Samden Khansa of A-K	20,576	30 47 55	91 25 54
R^{223}	21,543	30 50 38	91 29 40
R^{224}	20,130	30 30 33	91 52 9

Sir Charles Bell writes, "I spent about a week in the Re-ting monastery "north of Lhāsa, not far from the Nyen-chen-tang-lha; and whilst I was there, "discussed with a very intelligent Lama the spelling and meaning of the name of "this range. He gave the spelling as Nyen-chen-tang-lha. The meaning is "the spirit of the expanse of great fear. One is struck by the nearly equal "altitude of this long row of peaks. Hence perhaps the word tang, a level expanse. "The last syllable is not the La of a pass, but the Lha of spirit or god, the same word "as is found in Lhāsa, the place of the gods."

Bell also writes, "the word Kangri or Gangri means a snow-mountain, and "naturally figures largely on maps of Tibet. The initial letter K or G is pronounced "like a K rather deep down in the throat over the central parts of Tibet, and like "a G in the east and west. Personally I favour K, the Lhāsa pronunciation."

The following peaks of Trans-Himālaya were fixed in 1904 from the Tsangpo valley, by Colonel H. Wood who saw these peaks on his north:

Name.	Height in feet.	Latitude. ° ′ ″	Longitude. ° ′ ″
W^{215}	20,437	31 5 18	81 13 57
Kailās	22,028	31 4 2	81 18 50
W^{135}	21,600	29 55 16	84 33 33
W^{134}	23,150	29 50 4	84 36 39
W^{133}	21,300	29 48 49	84 38 8
W^{122}	20,628	29 43 16	85 10 11
W^{107}	20,616	29 26 45	85 21 44
W^{100} or Cho-ur-dzong	21,300	29 27 43	85 23 8
W^{86}	20,752	29 26 37	85 23 18
W^{88}	21,097	29 29 25	85 24 52
W^{87}	21.227	29 28 30	85 24 53
W^{60}	20,000	29 33 25	87 8 38

CHAPTER 16.

THE KUNLUN AND THE MUZTĀGH ATA.

The Kunlun range is the northern border of the Tibet protuberance, as the Himālaya is its southern border. Throughout the whole length of Tibet, from longitude 77° to 93°, the Kunlun is a continuous range of snow mountains, generally lower in height than the Himālaya but of a similar width. Since the first edition of this book was published in 1907, the remarkable series of explorations carried out by Sir Aurel Stein have added considerably to our knowledge of the Kunlun (see Chapter 9); a portion of the Eastern Kunlun is still however unexplored.

The two Kunlun ranges are known as the Northern Kunlun and the Southern Kunlun. The Southern Kunlun is the inner range, and as in the case of the Himālaya this inner range is also the main watershed. Sven Hedin regards the Southern Kunlun as "the highest range of the system," and Stein agrees with this view. Stein however found that the highest peak of the whole Kunlun, now well-known in geography under the name of Muztāgh (23,890 feet), is situated on the Northern Kunlun. In 1901 Stein surveyed the Kunlun south of Khotan: he entered the mountains by the debouchure of the Yurung-Kāsh river, the eastern branch of the Khotan river. He explored the deep rocky gorge through which this river has carved its way through the Northern Kunlun range: he discovered that the upper course of the Yurung-Kāsh lies in deep defiles which pass west and south of the great Muztāgh Peak. (*Memoir on maps of Chinese Turkistān* by Sir Aurel Stein, published as volume XVII, "Records of the Survey of India, 1923). Stein describes this peak as "the "culminating massif of the Northern Kunlun range." He writes of it as "the ever conspicuous pyramid of Muztāgh." It is thus clear that the Yurung-Kāsh rises between the two Kunlun ranges and that it has its sources both in the glaciers of Muztāgh and also on the northern slopes of the Southern Kunlun. The Keriya Darya and the Charchan Darya also pass through the Northern Kunlun and have their sources on the Southern. Stein also explored the bends and the Kunlun gorge of the Karakāsh, which is the western branch of the Khotan river. To the east of the Karakāsh gorge the Northern Kunlun is known locally as the Ulug Muztāgh.

In the following table a comparison is made between the two great border ranges of Tibet, i. e. between the Himālaya and the Kunlun.

——	Himālaya.	Kunlun.
Height of highest peak .	Mount Everest 29,002 feet	Muztāgh 23,890 feet.

—	Himālaya.	Kunlun.
Crest-lines . . .	There is only one main crest-line in the Great Himālaya.	There are two parallel crest-lines in the Kunlun, as in the Hindu Kush; they are known as the Northern Kunlun and the Southern Kunlun.
Length	1,500 miles	Length similar but not known with the same exactitude.
Average width from crest to plains.	From watershed range in Nepāl to plains 140 miles: from main crest in Punjab to plains 110 miles.	From Muztāgh peak on Northern Kunlun to plains 80 miles: from Southern Kunlun crest to plains 100 miles.
Height of plains at the foot of the mountains.	1,500 feet. If the plains in India were as high as those of Kunlun, the Siwālik range would be submerged and many of the outer Himālaya hills also.	4,500 feet. This great height of the bordering plains must diminish the visible width of the range.
Foot of the range . .	The Siwālik chain forms the foot of the Himālaya range.	Stein writes, "Throughout the whole length of the Kunlun the foot of its northern slopes is formed by a glacis of gravel 40 miles wide and utterly sterile."
Drainage	In Kumaun and Nepāl many rivers have cut through the great range to the watershed range in rear. In Punjab the main crest is a watershed. The Indus, Tsangpo, Sutlej and Karnāli bring drainage from Tibet across the Himālaya. The Indus and Tsangpo are longitudinal rivers in Tibet, in other words they have to flow for hundreds of miles behind the Himālaya before they can find an outlet from the plateau into India. The Karnāli is a transverse river. The Indus has a longitudinal tributary in the Shyok.	Drainage and rivers are relatively insignificant. The Yurung-Kāsh, the Keriya Darya, the Charchan Darya have their sources on the northern slopes of the South Kunlun range and cut through the North Kunlun. The Yārkand and Karakāsh are the only rivers that rise in Tibet: they are fed from the Karakorum and they cut through both the North and the South Kunlun ranges. The Yārkand is a longitudinal river, the Karakāsh is primarily a transverse river although it has to flow for over a hundred miles in a longitudinal trough between the two Kunlun ranges, before it can find an outlet from the plateau into the Takla Makān plains. The Yārkand has a longitudinal tributary in the Shaksgam.

—	Himālaya.	Kunlun.
Watershed . . .	In Nepāl and Kumaun the Himālayan watershed is a lesser range in rear of the main crest. In the Punjab the main crest is the Himālayan watershed. Four of the Indian rivers rise in Tibet in rear of the Himālaya.	In the Kunlun there are two parallel ranges: the southern is the main crest-line and it is also the main watershed. Two of the Turkistān rivers rise in Tibet in rear of the Kunlun.
Curvature . . .	The Himālayan alignment has a circular curvature concave to the north.	The Southern Kunlun alignment is linear and is not curved: the Northern Kunlun has a serpentine curvature changing from concave to the north in longitude 81° to convex in 87°.

It is customary in literature to refer to the "Western Kunlun" and the "Eastern Kunlun," the boundary being about longitude 82°: but these expressions are descriptions only and are in no way geographical names. The expression Northern Kunlun and Southern Kunlun are recognised geographical names.

From longitude 76° to 82° the North and South Kunlun ranges run parallel to one another about 20 miles apart. In longitude 82° they diverge; east of 82° the Southern Kunlun range (latitude 36°) continues without changing its alignment as far east as longitude 94°, but the Northern Kunlun changes direction to the north-east: the two ranges thus separate and in longitude 94° they are over 200 miles apart, the space intervening between them being known as the plains and swamps of Tsaidam. Where the Kunlun ranges diverge, the Northern Kunlun is named the Astin Tāgh (formerly the Altyn Tāgh) and the Southern Kunlun is named the Arka Tāgh. There is an unexplored gap of 200 miles in the Arka Tāgh (longitude 83° to 87°) but as a high range enters this gap from the west, and a high range emerges from the eastward end of the gap, Sven Hedin has concluded that the Arka Tāgh is a continuous chain.

"West of the unknown space," he writes (*Southern Tibet*, Vol. VII, p. 584), "we have the mighty Southern Kunlun system, and east of it are the no less "powerful ranges of Arka Tāgh, both systems with eternal snows and glaciers. "It may therefore be regarded as extremely unlikely that there should not be "a connection between the two."

Muztāgh Peak (23,890 feet).

This, the highest peak of the Kunlun, was observed by Sir Aurel Stein in 1900 and again in 1907. Stein's explorations gave rise to an historical puzzle that has attracted much attention.

In 1865 Mr. Johnson of the Survey of India travelled from Leh to Khotan, and he reported to General Walker that he had climbed the Muztāgh peak, then known as E 61. Mr. Hennessey, who was in charge of the computing office at Dehra Dūn, did not doubt that Johnson had climbed the peak, but he concluded from Johnson's report that the adopted height of the peak was too great by 1,000 feet. General Walker differed from Mr. Hennessey, he did not believe that Johnson could have climbed the Muztāgh peak at all.

In 1900 Sir Aurel Stein explored the same mountain area of the Kunlun that had been surveyed by Johnson 35 years before. Stein's surveys of 1900 revealed striking discrepancies between the actual topography and that represented in Johnson's map. The puzzle became even more difficult when in 1906 Stein resumed his explorations of the head-waters of the Yurung-Kāsh. Stein found that the Yurung-Kāsh river cuts a gorge 13,000 feet deep south of the Muztāgh peak, and he realised that if Johnson had climbed the peak, he must have crossed this deep gorge prior to the climb. But Johnson's map showed the course of the river to be north of the peak, and nowhere south.

Many years after Stein's explorations Major K. Mason became aware of this problem, and determined to investigate it. Mason could not conceive it possible that Johnson, who had a high reputation as a surveyor and who was an experienced triangulator, could have mistaken the position of the peak which he had climbed. Mason's first clue to the solution was found in Colonel Trotter's report of Kishen Singh's exploration in 1873: in this report was the following curious statement: "Mr. Johnson states that in his reconnaissance from the Kunlun, one of his three trigonometrically fixed points "on which his work was based turned out to have been incorrectly plotted on his "board." Mason could not find Johnson's original plane-table sketches, and when he examined the map made from them he found all three points correctly plotted. Mason quotes from General Walker's letter to the Government of India dated January 24, 1867: "Johnson's report would have been ridiculed had it been "published as it came from his pen. His map placed Elchi 40 miles north of "its true latitude. I sat him down by my side............ I showed him how "to correct his map .... I gave him more credit than he deserved, for "I said nothing about his mistakes."

Mason's investigation of this survey problem is very interesting and lucid; it was published in the Alpine Journal for November 1921 under the title "Johnson's "Suppressed Ascent of E 61," and it will repay the attention of mountain surveyors.

The puzzle had become widely discussed, the difficulties of solving it were considerable. It was not a straight-forward mathematical problem, but an intricate mixture of topographical errors due to wrong plotting. Different solutions had been advocated, and controversy had even become heated. It is therefore most satisfactory that the solution given in Major Mason's paper has been accepted.

on all sides. Mason's conclusions, the correctness of which cannot be doubted, may be summarised as follows (this quotation is abbreviated):—

"Though Johnson thought he had climbed peak E 61, it is certain that he was "not even on the range that contains it. It is probable that peak Zokputaran "(22,639 feet) was the actual peak he climbed. Johnson appears to have been "a better triangulator than topographer."

In Stein's Memoir on Maps of Chinese Turkistān, published in 1923 by the Survey of India, the Muztāgh peak is given the designation K^5. But the symbol K is a purely Karakorum symbol, and K^5 is a Karakorum peak. The original symbol for the Muztāgh peak was E 61, and in the original synopsis of triangulation it is called Kunlun No. 5: in the modern triangulation chart it is Peak 1/61A.

North-eastern Tibet.

South of the Arka Tāgh (latitude 36°) in North-eastern Tibet are the following parallel ranges which have been traced from about longitude 89° to 94°:

Koko-shili (latitude 35¼°)
Dunbure (latitude 34½°)
Tang La (latitude 33°).

The last named has been suggested as a possible easterly extension of the Karakorum (see frontispiece chart Part I). There is an error in the drawing of this chart: the north-easterly direction of the Astin Tāgh (called Altyn Tāgh on the chart) *should have been* continued as far east as longitude 94°, almost to latitude 40°; east of 94° its direction is from north-east to south-east, and at the change of direction the name Astin Tāgh is replaced by that of Nan Shan: it passes north of Lake Kuku Nor (Koko Nor) in longitude 100.°

Easterly Termination of the Kunlun.—As the Kunlun trends eastwards into China, it breaks up into minor ramifications, as the Hindu Kush does in Afghānistān. There is however this difference, that whereas the Hindu Kush does not split up into secondary folds until it has emerged from the high plateau and descended to lower levels, the Kunlun begins to throw off its branches before it has left Tibet. Eastern Tibet is very intricate, no surveys have been made, and it is not possible at present to analyse the mountains from existing data, or to determine the relations of the Kunlun to the numerous ranges that traverse western China between the Hoang Ho and Yangtze rivers.

The Koko-shili.—When Welby travelled in 1896 from west to east through northern Tibet he marched south of the Koko-shili range for a long distance. Sven Hedin explored the long trough to the north between the Koko-shili and the Kunlun. In longitude 94° 20′ the Koko-shili is cut through by a northern affluent of the Yangtze, but east of the gorge it becomes, under the name of Baian

Kara Ula, the water-parting between the Hoang Ho and Yangtze. Welby's "Abrupt" peak and the "King Oscar" peak of Sven Hedin rise from this range.

The Tangla.—The Tangla range forms the water-parting in Tibet between the Yangtze and Salween, and Prejevalsky traced an affluent of the former almost to its source in the Tangla at a height of 16,400 feet.

The explorer Kishen Singh traversed Tibet from south to north, from Lhāsa to Saichu, and crossed over several ranges: the following are extracts from the narrative of his journey in the interior of Tibet (J. B. N. Hennessey: "Report on the explorations in Great Tibet and Mongolia made by A-K in 1879-1882"):—

(i) "We reached the Lani La pass by an easy ascent of 2¼ miles. "The Lani La range comes from the east, and far off in that direc- "tion are some high peaks covered with perpetual snow."

(ii) "Tangla is a long range of mountains running from the west and pos- "sessing several snowy peaks and spurs."

(iii) "The Dunbure Khuthul pass has an easy ascent. The general direc- "tion of the long range bearing this name is from east to west."

(iv) "We crossed the Koko-shili Khuthul pass, which has an easy ascent. "The general direction of the range is from east to west."

(v) "A steep ascent of 1½ miles then brought us to the Angirtakshia "Khuthul pass. The Angirtakshia, a long range, lies east and west."*

The Muztāgh Ata and Sarikol Ranges.

The Muztāgh Ata and Sarikol ranges are two parallel mountain chains that form the eastern flank of the Pāmir plateau, and that trend from south-south-east to north-north-west (frontispiece to Part I). The more easterly of the two is the Muztāgh Ata range, called by Humboldt the Bolor and by Hayward the Kizil-Art. It rises like a wall from the Tārīm deserts, and is surmounted by glaciers and snow-clad peaks.

The Muztāgh Ata range is shown on the chart as a direct continuation of the Kunlun, on the authority of Stoliczka.

In 1900 Sir Aurel Stein made a survey of the Sarikol Valley, and Ram Singh carried triangulation along the Muztāgh Ata range. Ram Singh's triangulation showed that the Kungur† (or Shiwakte) section of the range rises in one peak Kongur-debe (25,146 feet) considerably higher than Muztāgh Ata (24,321 feet). Kongur-debe is the highest peak that is situated north of the Karakorum and Himālaya.

The Sarikol range.—The Sarikol range, running parallel to the Muztāgh Ata on the west and at a distance of 30 or 40 miles from the latter, is the lower range

*Angirtakshia is a local name for an easterly extension of the Kunlun.

† Sir Aurel Stein prefers the spelling Kongur.

of the two, and its peaks do not reach 20,000 feet. Nevertheless it is a primary water-parting of Asia, its western slopes draining into the Oxus and sea of Aral, its eastern into the Tārīm river and the lagoons of Lop Nor. The Sarikol range separates the Taghdumbash Pāmir from the Little Pāmir, and is crossed by the Nezatāsh (14,915 feet), the Uzbel (15,200 feet), and other passes.

The trough enclosed between the Muztāgh Ata and Sarikol ranges is known as the Sarikol valley; it extends from the Taghdumbash Pāmir to the Little Kara Kul lake. The plains of the Taghdumbash Pāmir form a southern continuation of the Sarikol valley; and the plains of Tashkurgan and of Tagharma are in the valley itself.

The Tashkurgan river drains the Taghdumbash Pāmir and the northern slopes of the Hindu Kush, and passes into the Sarikol valley: in the valley it bends at right angles, and piercing the Muztāgh Ata range escapes through a precipitous gorge to the plains of Tārīm. The northern portion of the trough between the Sarikol and Muztāgh Ata range is drained by the Ulu-Art and Ikebel-su rivers, which unite and force a passage through the Muztāgh Ata range at the Gaz defile.

APPENDIX 2.

MOUNTAINEERING IN ITS RELATION TO GEOGRAPHY.

We are on the eve of changes in India; it will be a misfortune when they come, if European geographers are divided into opposing camps over questions of place-names. The Survey of India is the geographical department of the Government: it keeps the Government in touch with the people on geographical questions. As a department it has derived great benefit from surveys made by mountaineers at high altitudes in the Karakorum: valuable geographical knowledge has on these occasions been gained. In the summer of 1892 Sir Martin Conway accompanied by Lieut. C. G. Bruce explored the Hispar, Biafo and Baltoro glaciers; he was the first mountaineer to make surveys of the higher Karakorum. (*Climbing and Exploration in the Karakorum-Himālaya*, 1894.)

Dr. and Mrs. Bullock-Workman spent many summers between 1898 and 1912 in surveying the Karakorum glaciers, and in exploring those of Haramosh and Nun Kun (*Two Summers in the Ice-Wilds of Eastern Karakorum*, 1917). They worked in helpful harmony with the Survey of India. The following was the last letter received by the Survey from Mrs. Bullock-Workman:—"I should be obliged if you could tell me whether the Survey regards the Hindu "Kush as the westerly extension of the Karakorum range. I should be glad to know this "before I refer to it.

Yours faithfully,

F. BULLOCK-WORKMAN."

During his long residence in Kashmīr Dr. Arthur Neve was in frequent communication with the Survey, and his explorations contributed to our understanding of the Karakorum. (*Thirty Years in Kashmir*, 1913).

In 1909 Dr. Longstaff discovered the peak of Teram Kangri: it had been hidden by other peaks from the Survey observers, and had escaped their theodolites. Dr. Longstaff's discoveries also brought to light large errors both in the original mapping of the Siachen glacier and in the alignment of the great Karakorum watershed.

The Survey has been indebted in more ways than one to General Bruce. He has known the Himālaya from end to end, and he has been able to speak Himālayan languages. He discovered the origin of the mysterious name Makālu,* and he was the first to hear the name Chomo Lungma from Bhotias. He has referred also to many other names. He gave Morshead a place in the Mount Everest Expedition, 1922. His book *Twenty Years in the Himālaya* has been the useful companion of many geographers, and the Survey has regarded him as their colleague.

After so many years of co-operation it will be a misfortune if a breach occurs or if ill-feeling arises between the mountaineers and the Survey over geographical names. Much as mountaineers have done to help the Survey, the latter have frequently helped the mountaineers: the maps of glaciers made by mountaineers have always been based upon the triangulation of the Survey: they have been dependent also upon the Survey heights.

The discoveries by the Survey of the peaks of K^2, of Gasherbrum and Masherbrum, of Rakaposhi, of Kunjut, Hunza-Kunji and Shyok-Nubra have been of paramount importance.

*See Chapter 3 of this book. Bruce traced the name Makālu to the river Kamalung.

When differences occur between the Survey and mountaineers over place-names, they can generally be traced to the facts, that the Survey is more in touch with people of the country, and attaches greater weight to local ideas. This was the reason why the Survey opposed Mr. Freshfield's attempts to attach the names Gauri Sankar and Chomo Kankar to Mount Everest. This was the reason why Morshead gave a footnote to the Everest map explaining that the Tibetan names were not real: this has been the reason why civil and political officers and sportsmen have always supported the Survey, for they are in touch with the hill people also. And this has been the underlying reason why the double names recently proposed for the Karakorum have been opposed.

It has been unfortunate that Dr. Longstaff should have felt it necessary to bring forward two complaints against the Survey in a public meeting in London of the Royal Geographical Society, one concerning a pass and one concerning a mountain. Such complaints, if argued in public, lead to class-feeling.

Dr. Longstaff complained that the name of a pass on the Karakorum was given on a survey map as Bilafond La instead of Saltoro La. The well-known mountaineers, the Bullock-Workmans, had adopted the name Bilafond La. The Survey has to deal with hundreds of passes many of which separate two races and thus have two names. It is not possible for it to know all the arguments for and against the alternate names of every pass: nor is it possible to give both names to a pass upon a map, for they conceal the hill drawing. It can be realised how the Survey accepted the name from Mrs. Bullock-Workman.

Dr. Longstaff himself had stated in 1910 that the local people " called the pass Bilafond La ". The Survey naturally attached weight to the name that was in common use amongst the local people. And both Dr. Longstaff and Mrs. Bullock-Workman were in agreement about this name. As Dr. Longstaff had been the discoverer of the Saltoro Pass, of the upper part of the Siachen glacier and of Teram Kangri peak, his authority was recognised and his decision would have been accepted by the Survey as final. Until I heard Dr. Longstaff's speech at the Royal Geographical Society in 1930, I had no idea that he objected to the name Bilafond La. I was taken completely by surprise. Twenty years had elapsed, and my memory did not enable me to reply to Dr. Longstaff's complaint. I listened to it with regret. When afterwards I consulted Sir Gerald Lenox Conyngham, who had been Superintendent of the Trigonometrical Survey at the time, he shared my astonishment. As this is an exceptional case, in which a geographical name had obtained an important place in history before its exact application and local meaning had been discovered, the question will be considered again in Chapter 18 (Part III) upon " Glaciers and their surveys".

On one occasion the Survey received the following letter from Mr. MacKinnon, the distinguished Himālayan naturalist :—

" I do not know where you got your name Borendra for the pass leading into the Baspa. I have crossed it several times, and on each occasion the hill-men with me have called it the Buranghati. I thought you might like to know this." Such a letter is helpful and would be sure of receiving attention. Everyone would wish to support Dr. Longstaff when he strives to maintain historic tradition. But on occasions there are different interpretations of history and then the only remedy is co-operation.

I have already referred in Chapter 3 to the controversy over the mountain name Karakorum. and have explained how this name entered into geography in 1820 and how it came to be accepted by the Survey in 1876. I only refer to it again to show how disagreements over history may

arise. The name Karakorum was adopted in 1876 in preference to Muztāgh by high geographical authorities. Since 1876 this name has been in use by the Government of India and by the Government of Kashmīr; for two generations it has been taught in geographical text-books in the schools of India, Europe and America; and it has been accepted by European geographers and scientists, by civil and political officers, by the army authorities, by the resident populations and missionaries and by generations of the travelling public. To displace such a name from its traditional place is a step that requires an overwhelming case: before the Surveyor General of India could sanction its displacement he would have to be prepared to meet objections from all sides. At the meeting of the Royal Geographical Society at which the name Karakorum for the mountains of Baltistān was being discussed, Dr. Longstaff explained his primary reason for preferring the name Muztāgh to Karakorum, and he spoke as follows:—" I am very keen " on the historical side of this question. The first man whose writings are of practical interest " to the mountaineer is Vigne, and Vigne speaks of the Muztāgh." Everyone will sympathise with Dr. Longstaff's historic feelings, the Survey bases its nomenclature upon history; but Dr. Longstaff means " mountaineering history "; and the Survey means " geographical history", and the two histories are not in accord. The following list shows the names allotted to the mountain range of Baltistān in geographical history, before the Survey of India had commenced their surveys:—

1820. Moorcroft had used Karakorum.
1830. Humboldt had used Karakorum.
1842. Vigne used Muztāgh (map dated 1842).
1850. Alex. Cunningham used Karakorum.

Dr. Longstaff ignores Moorcroft because he was not a mountaineer. Mountaineering history begins with Vigne. But mountains have not as a rule received their names from men climbing to their summits: the name Himālaya was given to the snowy range by people living at low levels and beholding the range from below. The name Dhaulāgiri (white mountain) was obviously introduced by people who had a distant view of the mountain: at a distance the whiteness is its distinctive feature, but this whiteness ceases to be the distinguishing mark when the observer is so high as to be surrounded by snow peaks on all sides. The mountain name Bandarpūnch (monkey's tail) seems very appropriate at a long distance, as the resemblance of the peak's outline to a monkey's tail is striking, but this resemblance is no longer apparent when the observer climbs above the snow-line.

MGIPC—S4—III-5-5—11-3-33—1,000.

CHART IX

Chart
illustrating the PARALLELISM
between the borders of
the old Peninsular Table-land and
the Central Asian Highlands

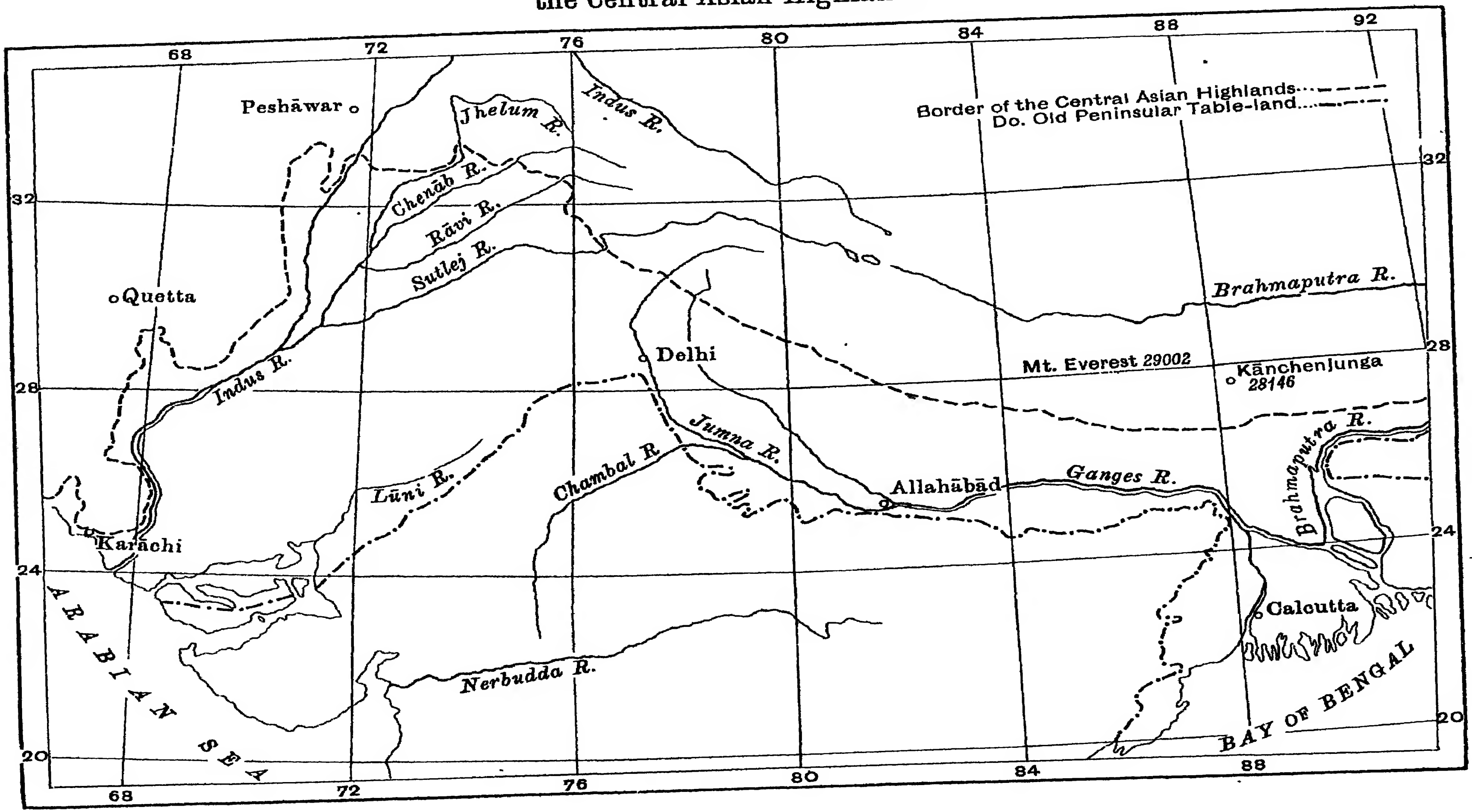


CHART XII

Diagram to illustrate
Brian Hodgson's theory of
HIMĀLAYAN CONFIGURATION
1848

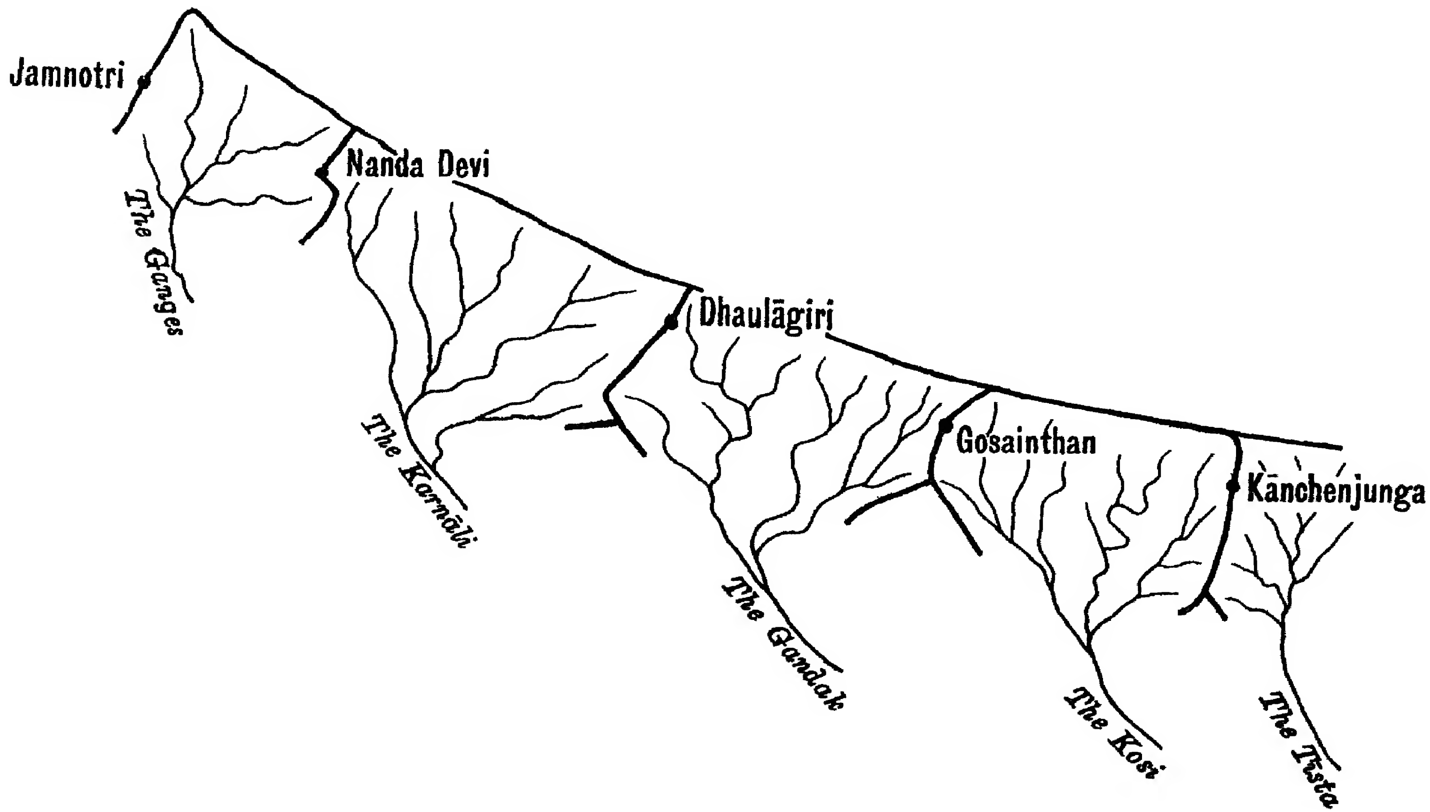
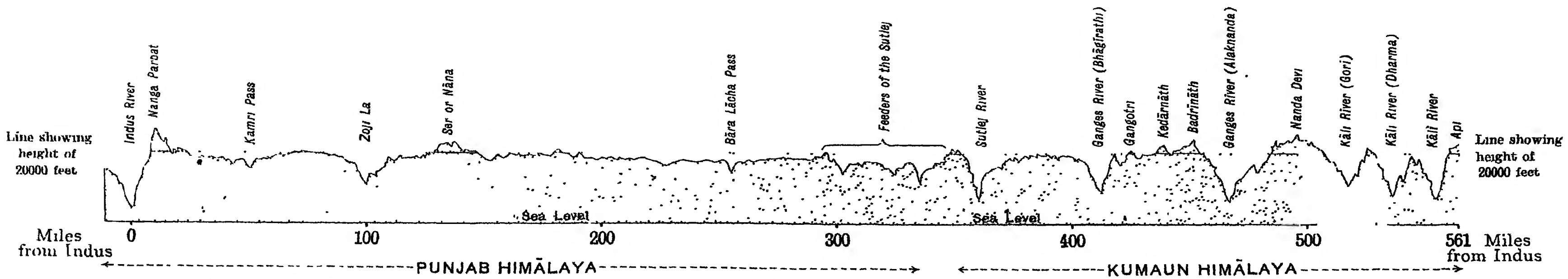


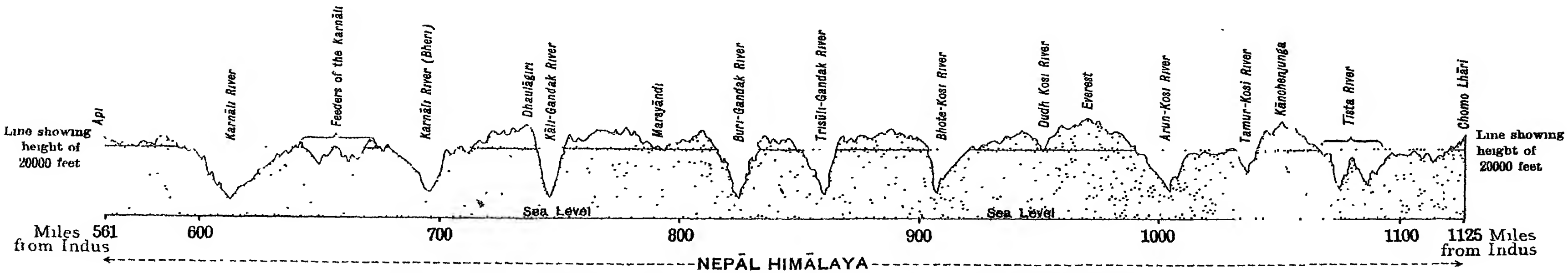
CHART XIII

SECTION
along the GREAT RANGE of the HIMĀLAYA
from the INDUS to the TĪSTA
showing how it is being cut
by the rivers into isolated blocks



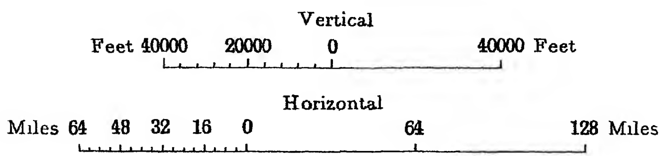
But few peaks exceed 21000 feet. The water-parting coincides with the main Range.

Many peaks exceed 22000 feet.
The water-parting is situated 20 or 30 miles behind the main Range.



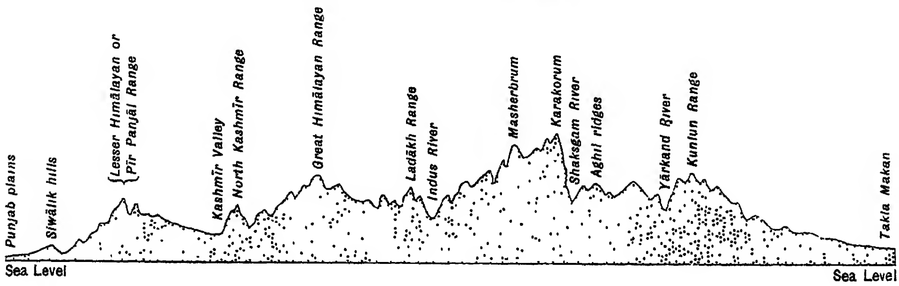
Many peaks exceed 25000 feet. The water-parting is situated 50 or 60 miles behind the main Range.

SCALES

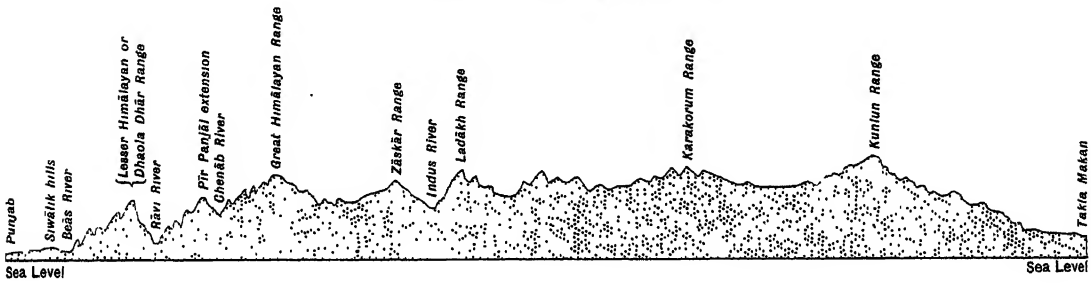


DIAGRAMMATIC CROSS SECTIONS of the HIMĀLAYA
drawn at right angles to the Great Range
Cross-Sections 1 to 4.

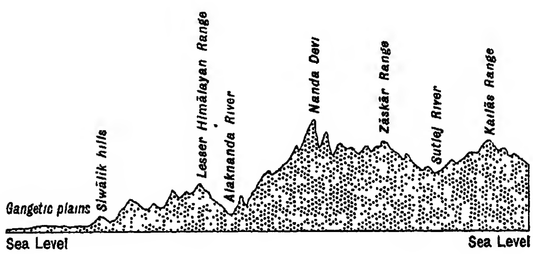
No. 1 THROUGH KASHMĪR.

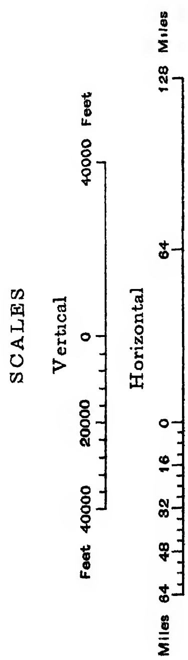


No. 2 THROUGH KĀNGRA AND TIBET.



No. 3 THROUGH NANDA DEVI.





No. 4 THROUGH DHAULĀGIRI.

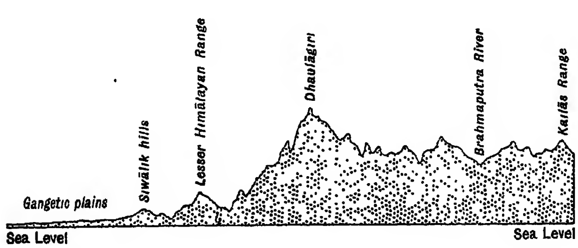
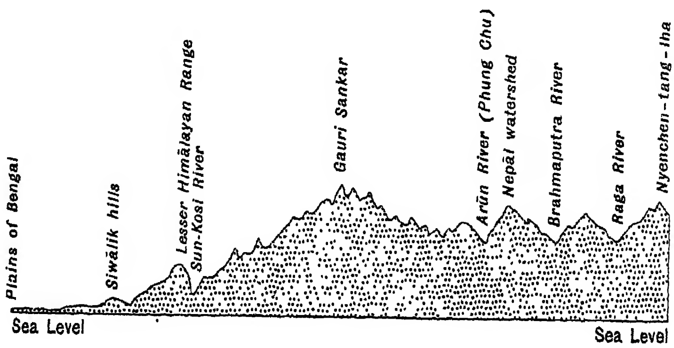


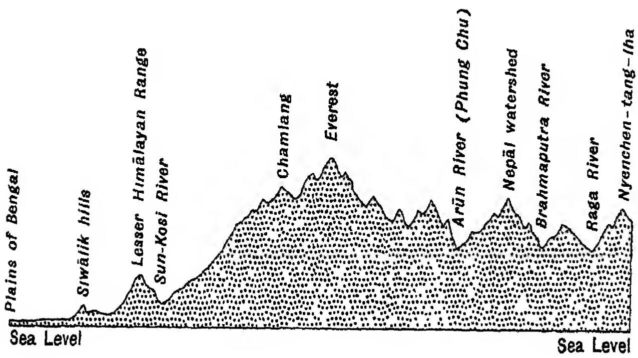
CHART XV

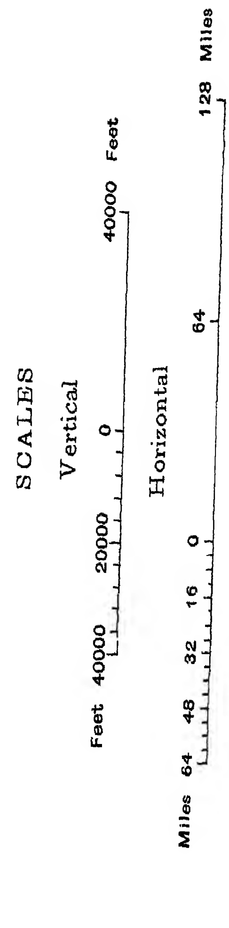
DIAGRAMMATIC CROSS SECTIONS of the HIMĀLAYA
drawn at right angles to the Great Range
Cross-Sections 5 to 7.

No. 5 THROUGH GAURI SANKAR.



No. 6 THROUGH MOUNT EVEREST.





No. 7 THROUGH KĀNCHENJUNGA.

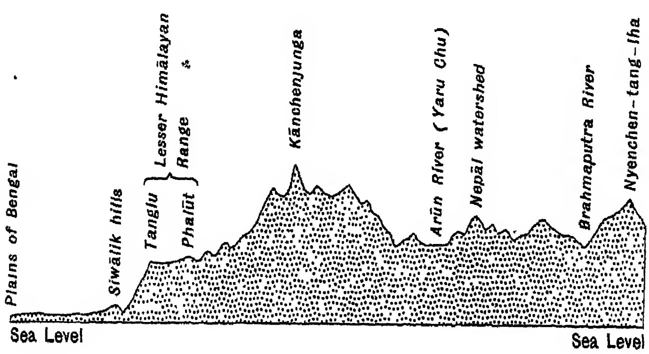


CHART XVI

BIFURCATIONS of the GREAT HIMĀLAYAN RANGE.

Scale 1″ = 32 Miles

FIGURE 1.

Bifurcation near Dhaulāgiri

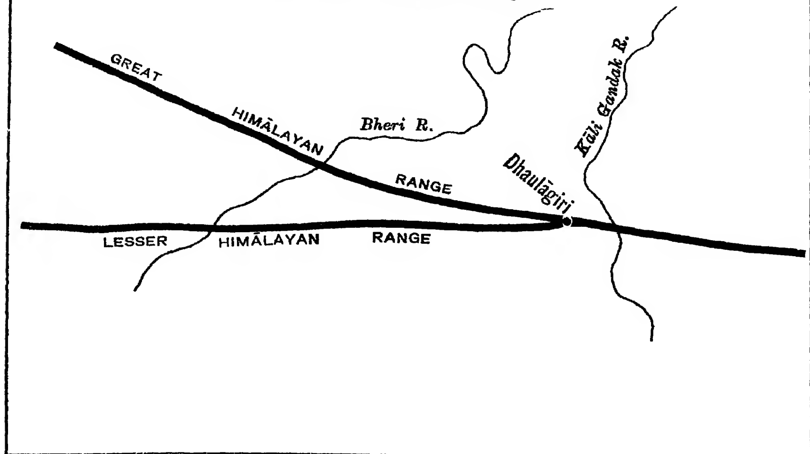


FIGURE 2.

Bifurcation near Nampa

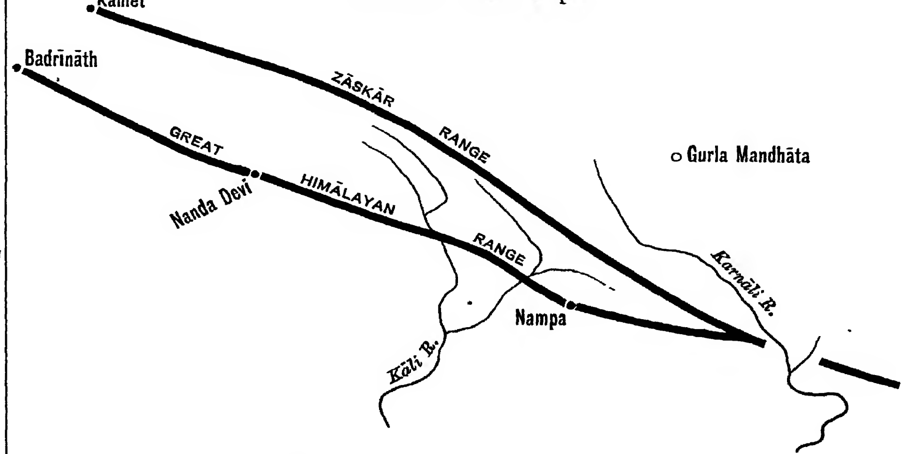
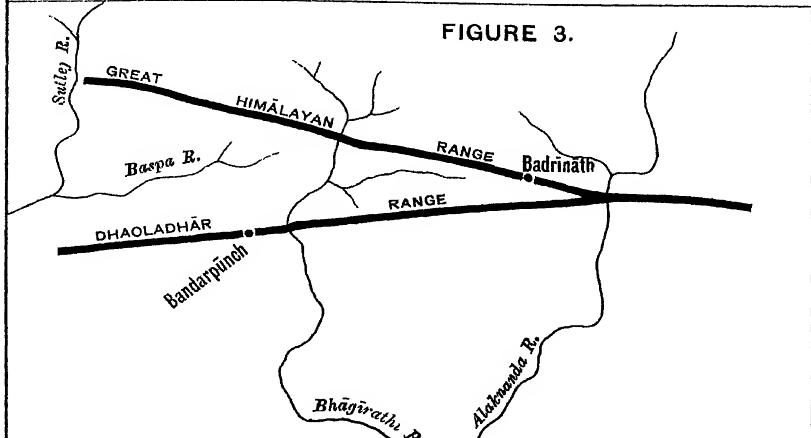
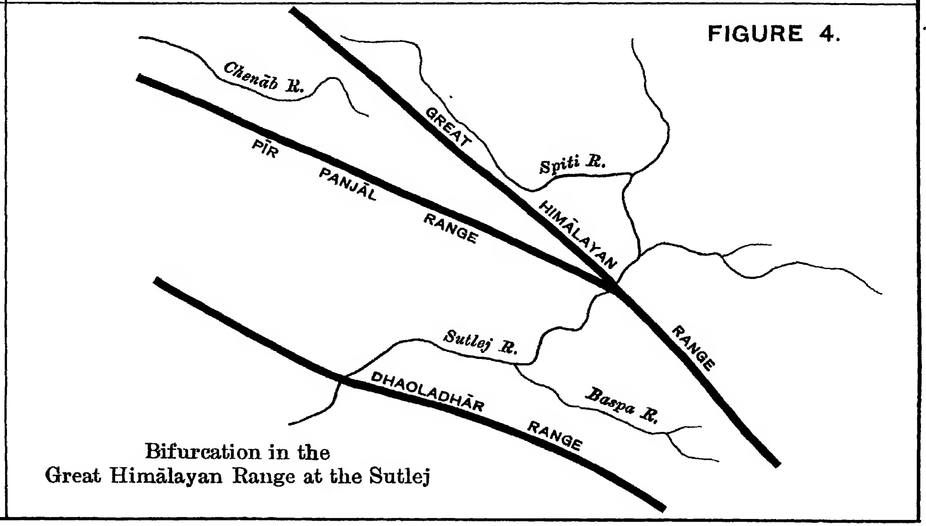


FIGURE 3.



Bifurcation near Badrīnāth

FIGURE 4.

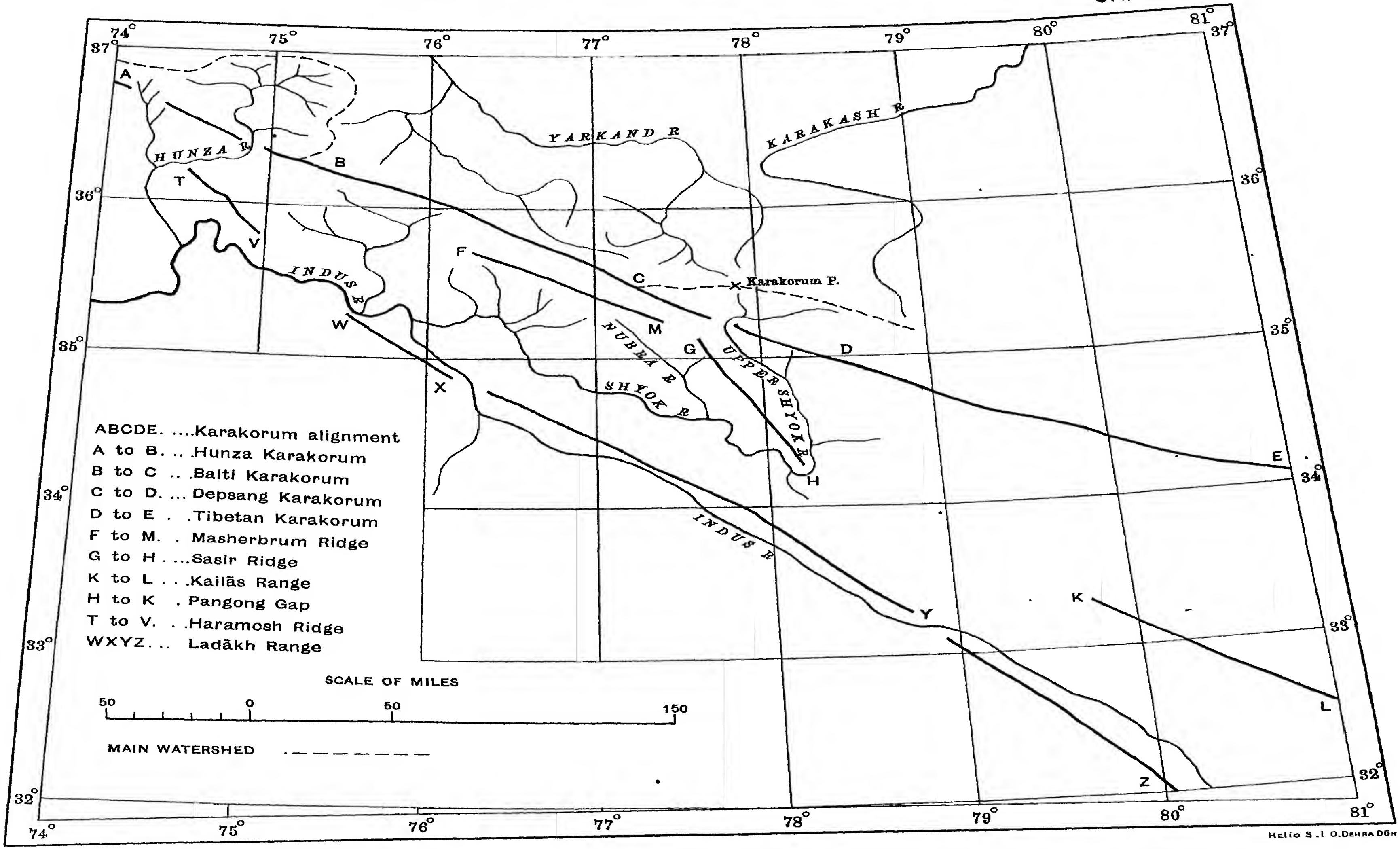


Bifurcation in the
Great Himālayan Range at the Sutlej

DIAGRAM to ILLUSTRATE

Firstly, the conjunction of the Karakorum, Kailās and Ladākh Ranges in Western Tibet.
Secondly, the positions of the Sasir and Haramosh Ridges.

CHART XVII

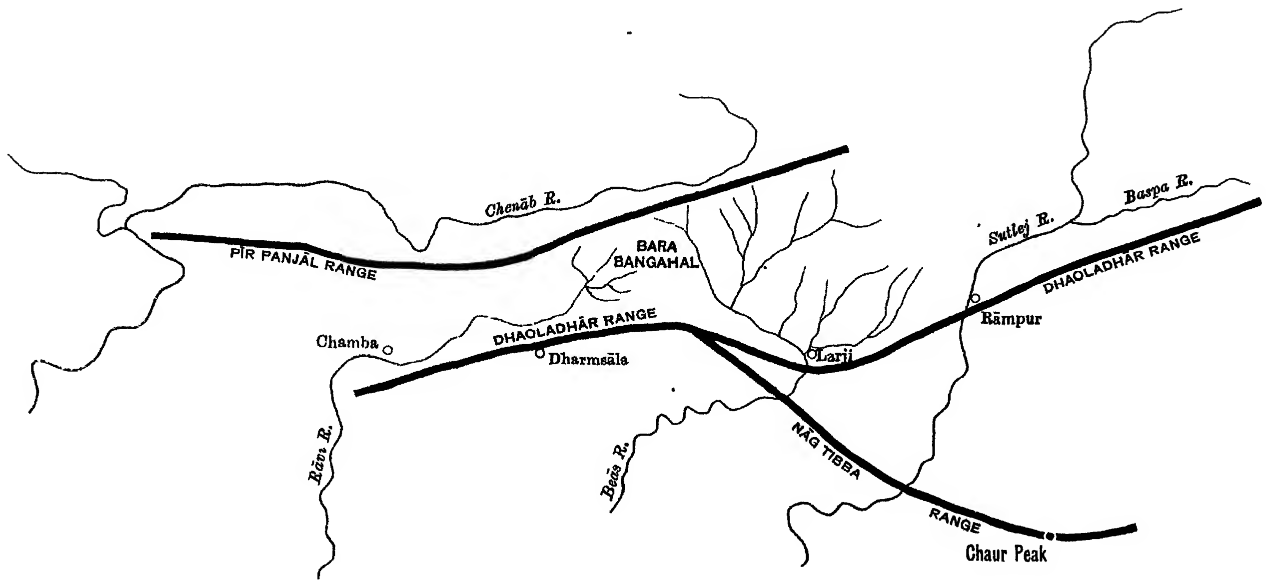


Reg No 184 D D D 1931

Helio S. I. O. Dehra Dūn

Conjunction of Ranges at the Source of the RĀVI

Scale 1″ = 32 Miles



Lessons from the SIWĀLIK Range

CHART XIX

FIGURE 1.

Bifurcation of the Siwālik Range
South of Kāngra

Scale 1″ = 4 Miles

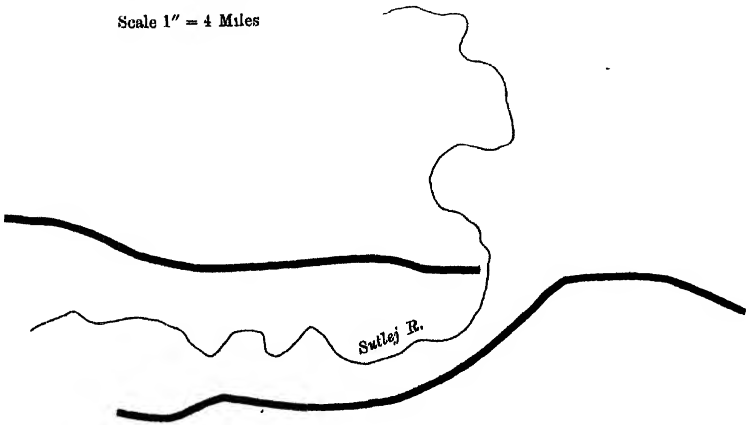


FIGURE 2.

Passage of the
Sutlej through the Siwālik Range
at the place where the range
alters its alignment

Scale 1″ = 32 Miles

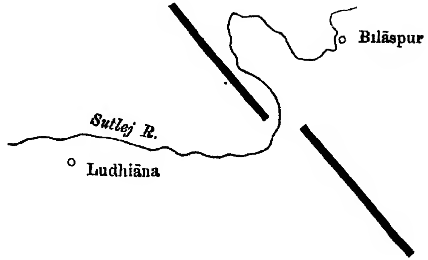


FIGURE 3.

Bifurcation of the Siwālik Range near Dehra Dūn

Scale 1″ = 4 Miles

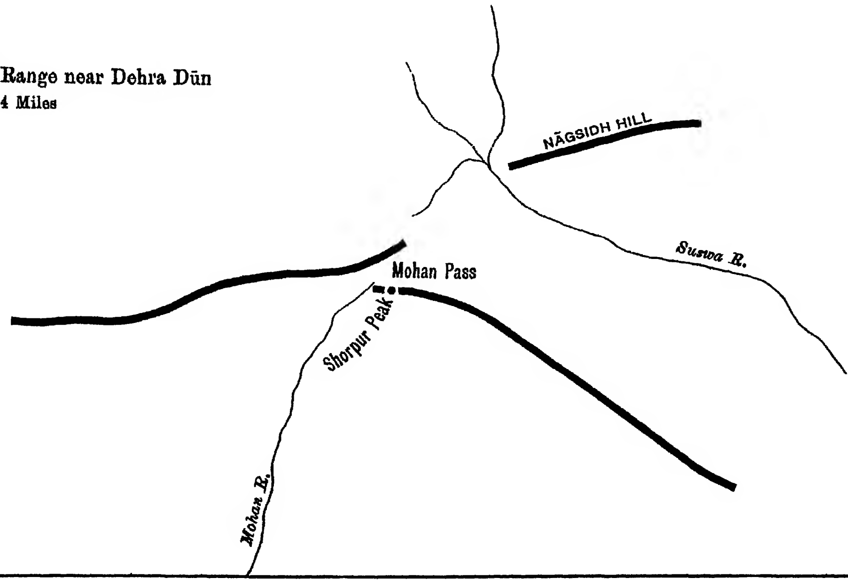
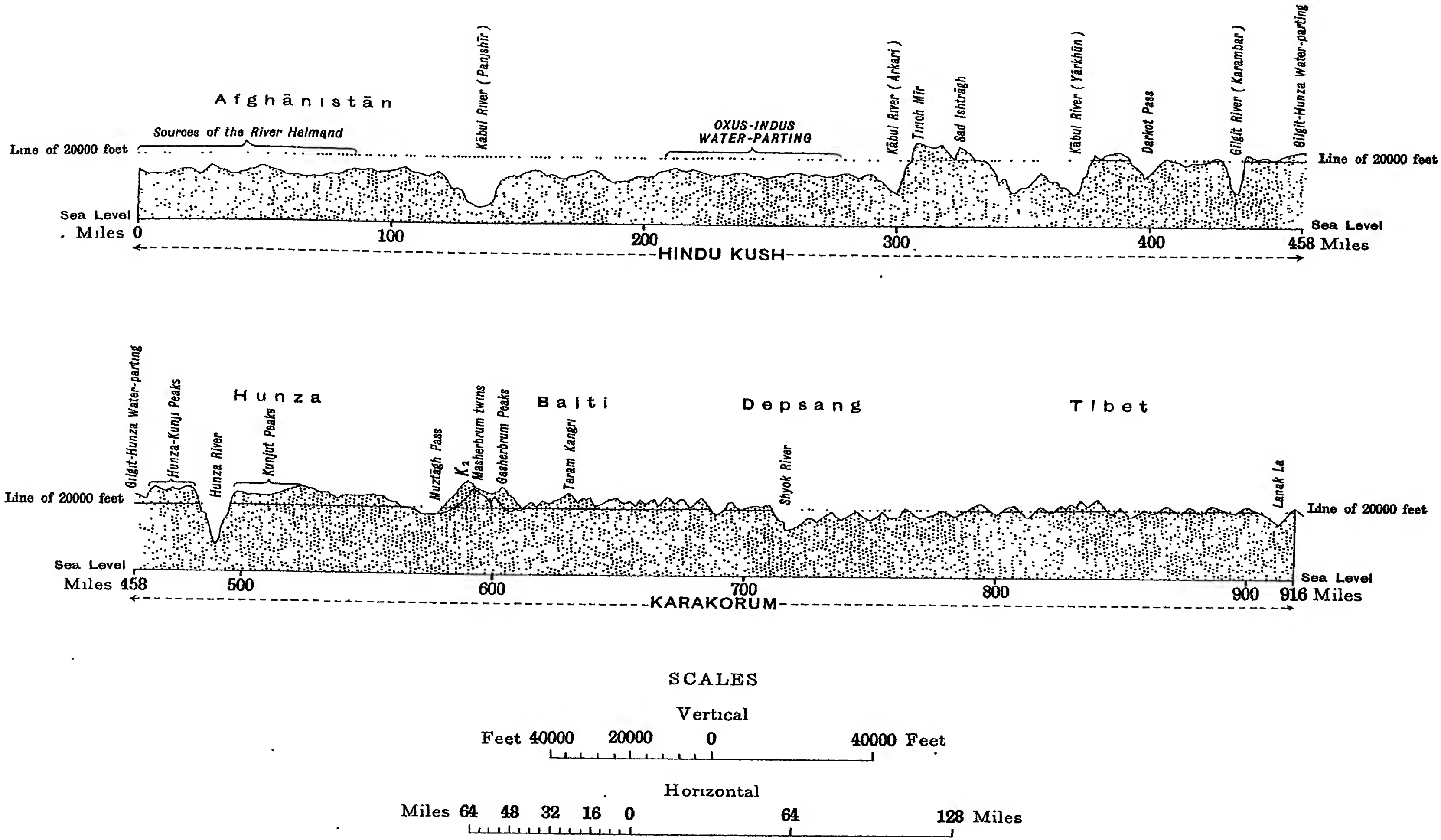


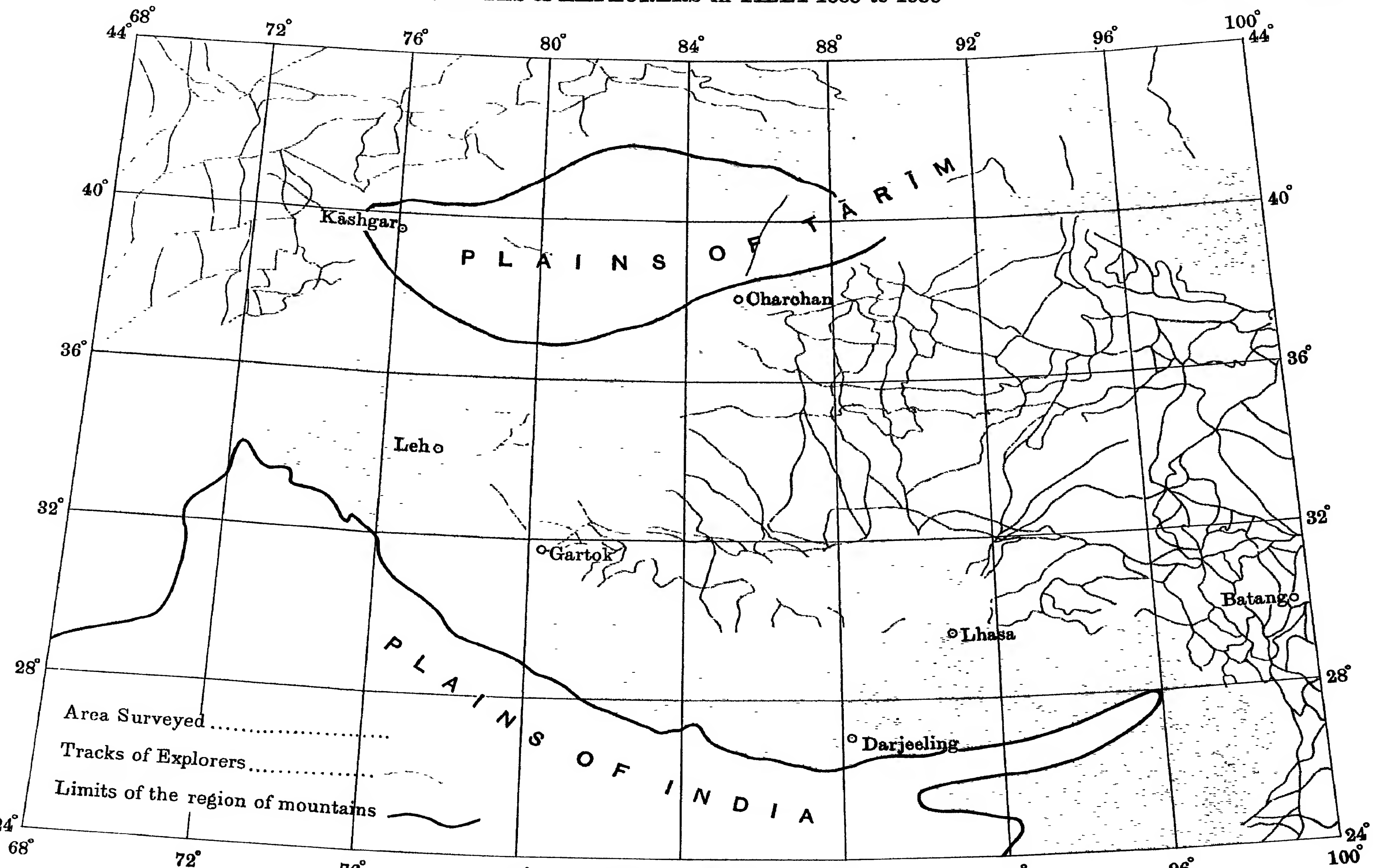
CHART XX

SECTION
along the crest line of the
HINDU KUSH-KARAKORUM RANGE
from Afghānistān to Tibet
showing how the range is being cut
by rivers into isolated blocks



ROUTES of EXPLORERS in TIBET 1865 to 1930

CHART XXII



Scale 1 Inch = 256 Miles

REG. No. 162. D. D. D–1931

Heliozincographed at the Survey of India Offices, Dehra Dūn

THE GLACIERS AND RIVERS OF THE HIMĀLAYA AND TIBET.

CHAPTER 17.

THE SNOWFALL AND RAINFALL.

NO Himālayan problems have undergone such vicissitudes during the last half century as those relating to snowfall. As our scientific knowledge has been widening, our conclusions have been undergoing changes slowly and imperceptibly. It is only by reading old reports that we realise how changes of thought have come about. Geographers have been confronted by three questions:

(1) How much snow falls upon the high peaks in a year?
(2) To what atmospheric current is this snowfall due?
(3) Is the snow of the high peaks being annually maintained, or is it slowly decreasing and melting away?

Towards the investigation of these problems three series of observations have been recorded—the first dealing with the movements of the snouts of glaciers, the second with the height of the "snowline," and the third with the rainfall. The observations that have been made of glaciers will be considered in Chapter 18, but this branch of research has so far not contributed towards a solution of the problems of snowfall. The movements that have been observed of the snouts of glaciers have been erratic; neither seasonal nor secular variation has been discovered.

The Snowline in the Himālayas.

In the 1907 edition of this book the following description of the "snowline" was given: "The 'snow-line' is the lower limit of perpetual snow,—the line "above which the snow resists the heat of summer, and below which it all dis- "appears for a certain time every year. Snow will remain unmelted in deep "ravines long after it has disappeared from neighbouring summits, but in deter- "mining the snow-line we have to consider not sheltered snow but snow exposed "to the rays of the sun."

"The snow-line is dependent upon temperature and snowfall, and to a lesser "degree upon wind. A light snowfall renders the line high; the temperature of "the air at the snow-line is always below the freezing point of water in regions "of scanty snowfall."

After 1907 the Survey made some observations of the snowline on the peaks of Bandarpūnch, and Badrīnāth. Such observations are beset with uncertainty, for the snowline depends on many factors. The high tide of the ocean can be

accurately mapped, whether the coast is precipitous or sandy, vertical or flat, because the sea-water makes a horizontal line: but the snow-tide, as it moves upwards in summer and downwards in winter, is seldom horizontal: it zigzags with the topography and the wind. Above 20,000 feet a mountain summit may appear all white throughout the year, except for a few dark precipices: at 18,000 feet it may still be white, but the dark spaces showing through the snow are more frequent and larger than at 20,000: at 17,000 feet the white portions are still decreasing and the dark spaces are still more in evidence: as the observer continues to depress his telescope he sees the remaining white areas being constantly invaded by the dark, but even at 15,000 or 14,000 feet some white markings, in narrow shapes and ending in points, are still visible. Colonel C. G. Lewis, Survey of India, writes: "On the southern side of the Hindu Kush the height "of the snowline varies by as much as 2,000 feet in different places. Immense "quantities of snow are transferred by wind from one side of the Hindu Rāj range "to the other." Estimations of the snowline in the Assam Himālaya (southern slopes) have varied from 14,500 (Morshead) to 18,000 feet (Meade) (*Records, Survey of India,* Vol. XXI).

For these reasons the estimated height of the snowline has never in itself been regarded as a fact of scientific importance, but its divergences upon different ranges, and upon the different slopes of the same range have formed the basis of theories and have had considerable influence upon thought.

On the Zāskār range and on the Karakorum, on the Hindu Kush and on the Kunlun all observers have placed the snowline higher on the southern slopes than on the northern. This difference may be attributed to the greater power of the sun's rays upon southern slopes than upon northern. But on the Great Himālayan range the snowline on the southern slopes has been always placed lower than on the northern.

On looking back upon discussions of snowfall in the Survey Department, I realise that four original explanatory ideas have been advanced each of which has in turn changed the direction of thought: no one of them has been directly opposed to the others, and our present conclusions have been partially based upon all. The four ideas may be described as follows:

1. Strachey's theory in 1849.
2. Hill's table of monsoon rainfall, 1881.
3. Eliot's estimate of snowfall on high peaks, 1901.
4. Walker's explanation of snowfall, 1913.

Richard Strachey's Theory, 1849.

On the southern slopes of the Great Himālayan range in Kumaun the snowline has been observed to be 3,000 feet lower than on the northern: it is easier to observe a *difference* between two snowlines than to observe the exact height of either, for in the observation of a difference the effects of personal equation tend

to cancel. The first observer to call attention to the difference of 3,000 feet between the snowlines on the southern and northern slopes of the Kumaun Himālaya was Richard Strachey in 1849. Since Strachey's time subsequent observers have shown that throughout the Himālaya from Assam to Kashmīr the snowline on the southern slopes is a few thousand feet lower than on the northern. This phenomenon of a low snowline on a southern slope,—that is lower by some thousand feet on the southern than on the northern slope,—is a rare phenomenon in Asia; it is a phenomenon that is only visible upon the Great Himālayan range.

Richard Strachey explained the presence of a lower snowline on the southern Himālayan slopes than on the northern by the theory that the southern slopes were exposed to the full force of the monsoon from the Indian Ocean, and that as the high Himālayan range cut off the greater part of the monsoon from the north, the snowfall that reached the northern slopes was less.

Strachey's theory was universally accepted for many years; it is perhaps still accepted in a modified form.

The distinguished Himālayan geologist, R. D. Oldham, has attributed the desiccation of Tibet and the dryness of its climate to the rise of the Himālaya mountains cutting off the moisture from the monsoon. And Oldham's view has at times been held to corroborate Strachey's theory of the snowlines. But Oldham and Strachey were referring to different periods: Oldham was reviewing the history of a long geological period, whilst Strachey was only endeavouring to explain the snowfall of our own time.

Hill's table of monsoon rainfall, 1881.

In the period 1870-1880 Mr. Hill, the meteorologist of Allahābād, carried out series of observations of the rainfall at different places and heights on the southern slopes of the Himālayas; in 1881 he embodied his results in a table known to meteorologists as Hill's Table:

Hill's Table.

Height above plain.	Mean height in feet.	Rainfall Ratio observed.
0 to 1,000 feet	435	1·61
1,000 to 2,000 „	1,300	2·65
3,000 to 4,000 „	3,350	3·91
4,000 to 5,000 „	4,730	3·46
5,000 to 6,000 „	5,710	2·20
6,000 to 7,000 „	6,370	1·89
10,000 to 11,000 „	10,660	0·12

It will be seen that Hill did not enter the actual rainfall in inches; he showed only the rainfall ratio between one altitude and another. His reason for adopting

this method was that the rainfall in Sikkim is greater than it is further west: it is greater too in Nepāl than in Kumaun or Kāngra; as the rainfall decreases from east to west, no locality can be put forward as a Himālayan standard. Nevertheless Hill did find that in every section of the Himālayas, whether it were Sikkim or Kumaun, the rainfall had a tendency to vary with altitude according to the law of his table. Whatever the total rainfall might be in Sikkim or Kumaun or Kāngra, the heaviest falls would be everywhere between 3,000 and 4,000 feet. In all districts the rainfall at 11,000 feet would be found to decrease approximately to one-thirtieth part of what it was at 4,000 feet. A law of this kind must not be tested too severely; it is a law of averages: rainfall is apt at times to be erratic: moreover Hill had to assume the Himālayan slope from 1,000 feet to be continuous up to 11,000 feet. Hill's table thus gives an approximate estimate of the rainfall to be expected under ideal conditions of slope: the inequalities in the topography, its rises and falls, ridges and ravines interfere with the operation of the law. The difficulty of working out a law that will enable the rainfall to be predicted without actual observations will be realised if we compare the rainfall actually observed at Chakrāta and Mussoorie: these two stations are only a few miles apart and are at approximately the same altitude, but the annual rainfall at Chakrāta is 72 inches and at Mussoorie 96.

Hill's law can be tested by taking the rainfall as observed by the Meteorological Department at certain low places, and then by calculating from the table what difference of rainfall would be predicted by Hill's theory at high places above. At Siliguri (1,000 feet) the average annual observed rainfall is 131 inches: by Hill's table therefore the rainfall above Siliguri at Darjeeling (7,000 feet) would be predicted to be about 113 inches: the mean rainfall actually observed at Darjeeling is 123 inches, or 10 inches more than Hill's prediction.

That the monsoon current drops the greater part of its rain before it reaches a height of 6,000 feet is proved by the meteorological observations in Assam: the annual rainfall at Cherrapunji (3,500 feet) is 428 inches, whereas at Shillong (6,000 feet) which is only 40 miles in rear of Cherrapunji the rainfall is 82 inches. Between the altitudes of 3,500 and 6,000 feet the rainfall has decreased by almost four-fifths. Hill's table would have made this decrease only one-half, and it thus did not err on the side of exaggeration. Hill's table is in serious disagreement with Strachey's theory of Himālayan snowfall. Strachey had assumed that the monsoon currents were giving snow above 20,000 feet and were crossing the Great Himālaya and producing snowfall on the northern slopes. Hill came to the conclusion that the monsoon gave hardly any rainfall above 12,000 feet.

Hill's table made it difficult to understand the snowfall of the Karakorum. The Karakorum range stands in rear of the Punjab Himālaya, the height of which is above 16,000 feet: if Hill's table were correct no moisture-bearing winds from the Indian Ocean could cross the Himālaya and give snow to the Karakorum: currents might penetrate the Zoji La (11,000 feet) and might pass

through the gorge of the Indus and get round the Himālaya north-west of Nanga Parbat, but such small currents could not carry sufficient moisture to account for the snow on the Karakorum.

In 1930 Dr. G. C. Simpson, F.R.S., Director of the Meteorological Office in England and formerly Meteorologist to the Government of India, wrote: "You "will see that Hill places the maximum rainfall as low as 3,350 feet above the "plain. His figures have never been modified and are generally accepted, and "my own experience in India gives me no cause to doubt that they are substan-"tially correct."

In corroboration of Hill's law many experienced sportsmen have recorded great decreases of rainfall when they have crossed the outer ranges and penetrated the interior of the mountains.

Eliot's estimate of snowfall, 1901.

I have had great diffidence in referring to Sir John Eliot's estimate of snowfall in 1901. He did not put it forward as the Director of the Meteorological Department in any published report. Dehra Dūn was one of his meteorological stations, and he stayed there a week during the summer of 1901. He told me in private conversation that he had for years been observing some snow peaks with a telescope mounted in the veranda of the Meteorological Office at Simla, and that he had come to the conclusion that their heights might possibly be changing by as much as 100 feet in the course of a year owing to the snowfall. This opinion from a high authority had considerable influence upon the Survey: if changes of such magnitudes were occurring, the values of the heights adopted for Himālayan peaks would require reconsideration. It was largely due to Eliot's influence that the Survey undertook in 1905-9 a long series of observations of the snow peaks of Badrīnāth, Kedārnāth and Bandarpūnch from the station of Nojli (See picture, Chapter 5, Part I). We observed these peaks every autumn and spring, but we failed to discover any definite variations in their heights. It is true that we were hampered by grazing rays and by the vagaries of atmospheric refraction: we had not then the knowledge of refraction that has been gained in recent years by the researches of Dr. de Graaff Hunter (*Survey of India, Professional Paper No. 14*, 1913: *G. T. S. Volume II*, Appendix 3). But making every allowance for the uncertainties due to refraction, we came to the conclusion in 1909 that the heights of the peaks of Badrīnāth, Kedārnāth and Bandarpūnch did not probably change by more than 5 feet during the course of a year and that they certainly did not change by as much as 10 feet. Colonel H. Wood, Survey of India, wrote in 1931: "It is possible that "what Sir John Eliot meant was that if a snow register was kept on a Himālayan "peak it might record a fall of 100 feet in the year. I have no idea of the amount "of snow that falls; but I am quite sure that from any high peak an enormous "quantity of snow is blown off by the wind very soon after it falls."

Although our results had not confirmed Sir John Eliot's estimate of height-change, we were indebted to him for his co-operation. It was due largely to his influence that a long series of observations came to be taken: and this series will be a permanent record of value, if ever our successors wish to test whether the Himālayas have been rising in height. Although our observations were affected by refraction, they will be reliable in future centuries if a *change of height* is being sought. Refraction will not change: it will in the future be the same as heretofore, and though it may prevent absolute values of height being determined with great accuracy, it will not prevent *differences* of height being observed.

In 1905 the Himālayas were shaken by the Dharmsāla earthquake and Dehra Dūn suffered severely. This fact contributed to our desire to make a complete series of height observations for the use of our distant successors.

The definite lesson learnt by the height-observations of 1905-9 was that the only certain method of measuring the annual amount of snowfall upon a high peak like Badrīnāth is for the observer to live for a year as near to Badrīnāth as he may find convenient. Its snowfall is too small to be observed at a distance of 100 miles.

Walker's explanation of Himālayan Snowfall, 1913.

It will be realised that at the beginning of the 20th century considerable uncertainty was prevailing concerning Himālayan snowfall. It was not that geographers were differing from meteorologists, for neither branch of science had been able to solve the problems.

In 1913 Sir Gilbert Walker wrote (Memoirs, Indian Meteorological Department, Vol. XXI, 1913): "The cold weather storms of northern India are of considerable "agricultural importance: their rainfall determines largely the character of the "great wheat crops of northern India, and they provide the chief part of the "snowfall whose melting feeds the irrigation canals during the hotter months of "the year."

The statement that the snowfall is mainly due to the "winter rains" explains many of our difficulties: Strachey had attributed all the Himālayan snow to the summer monsoon winds: Hill's table had also been based on observations of the monsoon. But Walker has now shown that it is the "winter rain" and not the monsoon, which gives to the Himālaya their snow.

The following extracts are from a letter which Sir Gilbert Walker has kindly written to me:

"The winter depressions from the west go on from December to May in the "mountain regions, the maximum being in April in much of Kashmīr. There "is practically no south-west monsoon in the Karakorum, so probably the greater "part of the snowfall occurs outside the monsoon."

"I feel sure that the monsoon does give precipitation up to 15,000 feet and "probably higher, though high up the amount would be small."

"The annual rainfall at Yatung in Tibet (north of Darjeeling) is 50 inches "which shows that the monsoon gets there rather freely, and the same holds over a "considerable area. At Shigatze in the Tsangpo Valley, snow in winter seldom "exceeds 12 inches, and its rainy period is June to August. At Gyantse there "are 12 wet days in July and 20 in August."

"My guess would be that occasional bursts of monsoon rain cross the lower "places in the main chain of the Punjab Himālayas and give a sprinkling to the "chain behind, but that most of it comes from the winter depressions."

"Nobody knows where the water of these depressions comes from: some "of it must come from the Mediterranean but most people think that an upper "damp current from the Arabian Sea feeds into it."

The meteorological diary which Sven Hedin kept during his travels in Trans-Himālaya and Tibet, 1906-1908 (*Southern Tibet*, Vol. VI, 1917), shows many storms but only occasional falls of snow and rain. From September to April he met with occasional falls of snow, and on one day in January 1907 he had a heavy fall of snow lasting all day. But in the summer months, June to August, his diary gives support to Walker's view that occasional bursts of monsoon do reach Tibet: in June 1907 Sven Hedin had only two rainy days, and only three in July, but in August 1908 he recorded rain on many days.

The effects of wind upon the snow of high peaks.

From observations of peaks in the Kumaun Himālaya I had derived the impression that in the course of a year high mountains must lose a great deal of snow owing to wind. I have seen snow peaks with an apparent snow-flag continuously attached to their summits, which made me wonder how any snow could be left at all. In 1908 I received the following letter from Colonel J. Fisher, commanding the 2nd Gurkhas in Chitrāl: "I have been waiting to get a good "photograph of Tirich Mīr: it stands out very clear, in a cloudless sky, but almost "always it has a flag of snow, being blown by the wind off its top."

In 1932 I received the following letter from Dr. G. C. Simpson, F.R.S.: "You "say that the snow-flags are so often to be seen on Nanda Devi and Tirich Mīr. "I wonder whether the effect to which you are referring is really produced by "drifting snow. There is a peculiar aerodynamic effect in the lee of a mountain, "when high winds are blowing which produces a lowering of pressure. As air "streams through this region of low pressure it expands with the formation of "cloud. This cloud remains stationary in spite of the heavy wind and has the "appearance of snow being driven off a mountain, but it really is not snow at all."

There can be no doubt that Dr. Simpson's explanation is correct.

The Rainfall in the mountains.

For many years geographers had been so impressed by the importance of the monsoon that they had based all problems of snowfall upon it. Sir Gilbert Walker has now taught us to give more consideration to the "winter rains," although they may appear slight, and less weight to the monsoon, although its rainfall is heavy. His pronouncement has brought relief to long-standing perplexities. The following tables of rainfall have been extracted from Vol. XXIII of the Memoirs of the Indian Meteorological Department. They show both the summer and winter rainfalls in the Himālaya.

The figures in the tables denote inches of rain: no meteorological observations have been taken above the snowline, but as an inch of rain is equivalent to a foot of snow, the figures opposite high Himālayan stations may be regarded to mean either inches of rain, or feet of snow. The rainfall recorded during the months May to October inclusive has been shown in the tables below as "monsoon rain," the rainfall from November to April inclusive has been shown as "winter rain."

Rainfall Table No. 1.

This table is not Himālayan: it refers to the Assam Hills, standing between the Himālaya and the Bay of Bengal.

Station.	Approximate height in feet.	Relative position.	Monsoon rain in inches.	Winter rain in inches.
Shillong	6,000	....	74	8
Cherrapunji	4,000	40 miles south of Shillong . . .	381	47

Rainfall Table No. 2.

The Sikkim Himālaya.

Station.	Approximate height in feet.	Relative position.	Monsoon rain in inches.	Winter rain in inches.
Yatung	15,000	In Tibet	40	10
Darjeeling.	7,000	In Sikkim	114	9
Siliguri	1,000	South of Darjeeling . . .	125	6

Rainfall Table No. 3.

The Garhwāl Himālaya.

Joshīmath is situated in the gorge cut through the great range by the Alaknanda, and the monsoon currents probably pass through this gorge. Srīnagar and Karnaprayāg are in a valley behind the Lansdowne range and are only 30 miles apart.

Station.	Approximate height in feet.	Relative position.	Monsoon rain in inches.	Winter rain in inches.
Joshīmath	6,000	In the Alaknanda gorge between Nanda Devi and Badrīnāth.	27	16
Karnaprayāg	2,600	In the Alaknanda gorge south of Joshīmath.	45	9
Srīnagar	1,200	On the Alaknanda in the hills below Karnaprayāg.	29	8
Lansdowne	6,000	On an outer Himālayan range which receives and breaks the force of the monsoon.	70	10
Hardwār	900	South of the Himālaya in the gap cut by the Ganges through the Siwālik range.	45	5

Rainfall Table No. 4.

In the outer Himālaya, Simla.

Station.	Approximate height in feet.	Relative position.	Monsoon rain in inches.	Winter rain in inches.
Simla	7,000	In the hills 30 miles behind Kasauli	52	11
Kasauli	5,500	On an outer range	52	9
Ambāla	800	In the plains south of Kasauli	30	4

Rainfall Table No. 5.

Kashmīr, Ladākh, Dardistān.

Station.	Approximate height in feet.	Relative position.	Monsoon rain in inches.	Winter rain in inches.
Leh	11,000	Ladākh	2	1
Skārdu	7,000	Baltistān	2	5
Kargil	9,000	North of and near Drās	2	7
Gilgit	5,000	Dardistān	3	2
Drās	10,000	North of the Zoji pass and of the Himālaya crest.	5	16
Sonāmarg*	8,000	South of the Zoji and Himālaya crest	19	51
Srīnagar	5,000	Kashmīr Valley	11	15

* Liable to heavy local rain.

RAINFALL TABLE No. 6.

North-West Frontier.

(Outside the Himālayan area.)

Station.	Approximate height in feet.	Relative position.	Monsoon rain in inches.	Winter rain in inches.
Chitrāl	4,000	North of Peshāwar	2	11
Malākand . . .	3,500	North of Peshāwar	18	18
Peshāwar	1,100	....	6	7
Abbottābād . . .	4,000	East of Peshāwar	29	18
Landi Kotal . . .	3,000	West of Peshāwar	4	10
Fort Lockhart . . .	4,000	West of Peshāwar	20	14

The actual snowfall on high peaks that are surrounded by large glaciers is probably greater than at points further distant, as the atmosphere above the glaciers must be colder than elsewhere. Owing to the presence of such glaciers as the Hispar, Biafo, Baltoro and Siachen there must be a local reduction in the temperature of the air in higher Baltistān, and when moisture-bearing currents pass over such a region its low temperature may possibly lead to a greater local snowfall than would be recorded at Skārdu or Leh (rainfall table 5). Similarly at the sources of the Ganges the glaciers of Gangotri, Kedārnāth, Satopanth and others might produce a local reduction of temperature which would cause passing currents to drop their moisture and which would give a greater snowfall to the peaks of Badrīnāth and Kedārnāth than has been recorded at Joshīmath and Karnaprayāg (rainfall table 3).

In the above tables the rainfall from May to October has been regarded as "monsoon rain," and that from November to April as "winter rain." This division between monsoon and winter is open to question. Sven Hedin quotes the following sentence from a letter from Dr. Walker: "A certain amount of "snowfall occurs in the N. W. Himālayas from our monsoon, but my belief is that "most of the snow falls during the winter and spring months (and even in May "and June) from depressions like those which give us our winter rains in northern "India." (*Southern Tibet*, Vol. II, 191). It appears therefore that the monsoon rains and the so-called winter rains may both occur in June, although brought by different currents. In a letter to me dated February 19th, 1932, Walker wrote: "Most of the rain behind the Punjab Himālayas comes from 'western "depressions': I used to call them 'winter depressions' although they may go "on to April and May."

The following extracts from diaries of sportsmen show how difficult it is to choose an exact date separating "winter rain" from "monsoon rain."

The rainfall noted in the diaries of sportsmen.

Diary of Lieutenant G. Burrard, R.F.A. in Higher Garhwāl, 1910

Date.	Locality.	Altitude of Camp (Barometric).	Observations.
		feet.	
5th May 1910 . .	Lower Bhāgīrathi Valley	4,000	Heavy rain.
11th May 1910 . .	Moneri on Bhāgīrathi	4,400	Heavy rain and thunder.
14th May 1910 . .	S. of Main Himālayan Axis in Bhāgīrathi Valley.	8,600	Little rain.
25th May 1910 . .	Gau Mukh, Gangotri glacier	12,960	Rain and snow.
29th May 1910 . .	Jhala on Bhāgīrathi	8,200	Rain.
5th June 1910 . .	Main Gorge of Bhāgīrathi	12,200	Heavy rain.
15th June 1910 . .	Main Gorge of Bhāgīrathi	11,200	Mist and rain.
17th June 1910 . .	Jhala on Bhāgīrathi	8,200	Rain all day.

Diary of Lieutenant G. Burrard, R.F.A. in Higher Garhwāl, 1911

Date.	Locality.	Altitude of Camp (Barometric).	Observations.
		feet.	
19th April 1911 . .	Moneri on Bhāgīrathi	4,400	Heavy rain all afternoon.
22nd April 1911 . .	Main Gorge of Bhāgīrathi	10,000	Rain in evening.
29th April 1911 . .	N. of Main Axis in Bhāgīrathi Valley . .	8,200	Little snow in afternoon.
30th April 1911 . .	Jhala on Bhāgīrathi	8,200	Little snow in afternoon.
6th May 1911 . .	Main Gorge of Bhāgīrathi	10,000	Thunder in afternoon, heavy snow in evening and all night
7th May 1911 . .	Jhala on Bhāgīrathi	8,200	Heavy rain and hail all afternoon.
18th May 1911 . .	Jhala on Bhāgīrathi	8,200	Thunder in evening.
22nd May 1911 . .	Jadhganga Valley	9,800	Rain and thunder in afternoon.
6th June 1911 . .	Tibet, beyond Zāskār range, Jelukhaga . Pass.	15,300	Very short snow storm in morning.
11th June 1911 . .	Jadhganga Valley N. of Nilang . .	11,600	Mist and a little rain *all from the North.*
14th June 1911 . .	Jhala on Bhāgīrathi	8,200	Steady rain all day but not heavy.
15th June 1911 . .	Bhāgīrathi Valley	5,400	Steady rain in evening.

Meteorological diary, 1927, by Colonel P. Neame, V.C., R.E.

Date.	Locality.	Altitude.	Minimum Temp.	Weather.
		feet.	°F	
August 14th to 17th	Kashmīr	8,000	49	Fine.
August 18th and 19th	Kishanganga Valley	11,000	46	Rain.
August 20th to 24th	Astor, Bunji, Gilgit Valley	6,000	76	Fine.
August 25th	Haramosh west slopes	5,000	67	Rain.
August 26th to 28th	Haramosh west slopes	11,000	31	Fine.
August 29th to September 1st.	Haramosh west slopes	10,500	35	Rain and snow.
September 2nd to 4th	Haramosh west	9,000	38	Fine.
September 5th to 15th	Haramosh west	11,000	34	Rain or snow daily.
September 16th and 17th	Haramosh south slopes	11,000	27	Heavy rain and snow.
September 18th to 25th	Haramosh south slopes	12,000	22	Fine.
September 26th to October 11th.	Astor, Kamri, Pahlwar, Gilgit Valley.	12,000	26	Cloudy but rainless.

Summary for 1927.—"During August and September once one got out of the "Indus and Gilgit Valleys into the higher nullahs of Haramosh above 9,000 feet "one got continual cloud and slight rain, with snow usually above 11,000. Indus "and Gilgit Valleys always seemed to have bright sunshine, but there were clouds "round the Haramosh peaks, during first three weeks of September, producing "rain and snow in moderate quantities."

Meteorological diary, 1928, by Colonel P. Neame, V.C., R.E.

Date.	Locality.	Altitude.	Minimum Temp.	Weather.
		feet.	°F	
April 2nd to 14th	Kashmīr to Leh	10,000	10	Fine except rain and snow on 5th.
April 15th to 17th	Ladākh	11,600	30	Rain daily.
April 18th to May 15th	Hanle, Pangong, N. E. Rudok, Tibet.	16,000	9	Fine but cloudy at times, occasional icy gale.
May 16th to 19th	Shyok river	14,100	11	Icy gales and snow.
May 20th to 22nd	Shyok to Indus	11,900	29	Slight clouds.
May 23rd	Near Leh	11,600	34	Snow.
May 24th to 27th	Indus Valley near Leh	12,300	36	Fine.
May 28th and 29th	Ladākh NW. of Leh	12,800	27	Snow and rain.
May 30th to June 2nd	Ladākh	10,600	43	Cloudy.
June 3rd to 6th	Ladākh	12,100	40	Rain.
June 7th to 15th	Northern Zāskār	12,000	..	Fine.
June 16th to 18th	Zoji La area	11,000	..	Snow and rain.
June 19th and 20th	Kashmīr	11,000	..	Rain and snow.
June 21st to 24th	Kashmīr	6,500	..	Fine.

Summary for 1928.—"During April, May, June, in Ladākh-Rudok one got "very few spells of continuous fine weather: there were a great many cloudy days "with occasional rain or snow."

Meteorological diary, 1929, by Colonel P. Neame, V.C., R.E.

Date.	Locality.	Altitude.	Minimum Temp.	Weather.
March 1st to 21st . .	Kashmīr	feet. 5,000 to 10,900	°F 34 to 5	Fine.
March 22nd to 26th .	Baltistān	10,700	22	Snow every day.
March 27th to 29th . .	Baltistān	7,800	27	Fine.
March 30th . . .	Baltistān	7,650	27	Rain.
March 31st to April 1st .	Baltistān	7,550	30	Fine.
April 2nd to 8th . .	Baltistān Shigar Valley .	7,700	30	Rain daily.
April 9th to 16th . .	On the glaciers at head of Shigar Valley.	11,300	17	Fine.
April 17th to 26th . .	Baltistān	10,900	20	Fine.
April 27th to 28th . .	Kashmīr	10,000	19	Fine.
April 29th to May 4th .	Kashmīr	8,500	32	Rain daily.
May 5th to 10th . .	Kashmīr	7,050	30	Fine.

Summary for 1929.—"During my stay in Baltistān in March and April "the weather was bad for a fortnight at the end of March and beginning of April: "it then became fine."

CHAPTER 18.

THE SURVEYS OF THE GLACIERS AND OF THE SNOWS.

The maps published by the Survey of India are shown in the catalogues and it is not necessary to give lists of them here. It is however advisable to refer to the problems that have had to be considered during the last century, and to explain how surveys of the higher regions of glaciers have been made by mountain explorers and why the flanks of the high peaks have been omitted from survey programmes. The chapter has been sub-divided into the following sections :

(1) The longest glaciers.
(2) Observations of the Geological Survey in 1906.
(3) Montgomerie's account of the Karakorum Glaciers in 1862.
(4) The surveys of the Karakorum in 1860.
(5) Sir Martin Conway the first mountaineer-surveyor.
(6) The surveys of the Workmans.
(7) The explorations of Dr. Longstaff.
(8) The surveys of Sir Filippo de Filippi.
(9) The glacier-surveys of Mr. and Mrs. Visser.
(10) The Shaksgam Valley.
(11) Professor Dainelli's expedition, 1930.
(12) Views of military officers.
(13) The recent glacier-surveys of the Hindu Kush.

(1) The Longest Glaciers.

Glaciers are rivers of ice which collect in the ravines and valleys of the high snow peaks and ranges, and which move slowly downwards, until they reach the point where their ice melts. The lower end of a glacier is known as its snout, and at its snout there is an "ice-cave" from which water issues. The change from ice to water marks the "source" of a river: every such ice-cave is a source of a river. The ancient Hindus gave the name Gau Mukh (the cow's mouth) to the ice-cave near Gangotri, which appeared to them to be the principal source of the Bhāgīrathi branch of the Ganges.

A mountain river like the Ganges has sources at all altitudes from which water is issuing, but only those sources that spring from the high snow-fields have their origins in glaciers. The number of Himālayan glaciers is almost countless, for small glaciers form in ravines at high altitudes and then like mountain streams they converge as they descend and combine to form a great river of ice which flows to the ice-cave.

When glaciers are tabulated according to their lengths they are found to fall into two classes, the longitudinal and the transverse. The longitudinal are the longer, and they lie in long level troughs parallel to the main range of the mountains; the transverse are those which flow down to low levels in directions more or less perpendicular to the main range. In the Karakorum the rocky surface of the mountains is traversed by long troughs of gentle gradient parallel to the crest-line, but no such troughs exist in the Himālaya; the great longitudinal glaciers of the Karakorum are thus longer than any glaciers of the Himālaya. In the Himālayan Journal, Vol. II, page 137, the eight longest glaciers of Asia were classified by Major Mason as follows:

Glacier.	Region.	Length (miles).	Height of snout (feet).
Fedchenko	Trans-Alai	48	9,880 approx.
Siachen	Karakorum	45	12,150
Inylchek	Tien Shan	44	9,100 approx.
Hispar	Karakorum	38	10,500 approx.
Biafo	Karakorum	37	10,360
Baltoro	Karakorum	36	11,580
Batura	Karakorum (Hindu Kush)	36	8,030
Koikāf	Tien Shan	31	11,320

The following details concerning these glaciers were also given in the Himālayan Journal:

Fedchenko.—Discovered in 1928 by the Russo-German expedition.

Siachen.—Discovered in 1848 by Henry Strachey: lower part of the glacier surveyed in 1862 by E. C. Ryall, Survey of India. Its great length of 45 miles was discovered by Dr. T. G. Longstaff in 1909.

Inylchek.—Merzbacher's map.

Hispar, Biafo, Baltoro.—Explored and surveyed by the Survey of India, Sir Martin Conway, the Workmans, the Duke of the Abruzzi.

Batura.—Explored and surveyed by the Survey of India, and Dr. and Mrs. Visser.

Koikāf.—Merzbacher's map.

(2) Observations of the Geological Survey in 1906.

In 1906 the Geological Survey of India took an important step towards determining the secular variation of the Karakorum and Himālayan glaciers. In the summer of 1906 five officers of the Geological Survey were deputed to make surveys of the ice caves and snouts of certain glaciers in Dardistān, Baltistān, Lahaul and Kumaun. Their reports accompanied by maps and photographs were published in the Records of the Geological Survey of India, Vol. XXXV, July, 1907. The positions of the snouts of the glaciers were marked by pillars

and cairns and rock-cuts. The following glaciers were surveyed during the geological expeditions of 1906:

Glacier.	Surveyor.	District.
Himarche	H. H. Hayden	Hunza, south-east of Rakaposhi.
Barche	H. H. Hayden	Bagrot valley, Rakaposhi.
Minapin	H. H. Hayden	Nagir, north of Rakaposhi.
Yengutsa	H. H. Hayden	Nagir.
Hasanābād	H. H. Hayden	Hunza.
Hispar	H. H. Hayden	Hunza.
Sonapani	H. Walker	Lahaul.
Bara-Shigri	E. H. Pascoe	Lahaul.
Pindari	G. de P. Cotter, J. C. Brown	Kumaun.
Milam	G. de P. Cotter, J. C. Brown	Kumaun.
Shankalpa	G. de P. Cotter, J. C. Brown	Kumaun.
Poting	G. de P. Cotter, J. C. Brown	Kumaun.

Centuries may elapse before any indication of secular variation can be obtained, and it is therefore a matter of scientific importance that the marks placed by the geological surveyors in 1906 should be periodically inspected and repaired. The existence of old moraines at lower levels shows that there has been a general retreat of glaciers since pre-historic times, but the observations of glaciers themselves during the last century have not as yet been sufficiently prolonged to indicate any definite proof of secular variation having occurred in the historic period.

In 1930 the Geological Survey published a paper by Major K. Mason, M.C., R.E., in which a history was given of the observations of thirty-four glaciers in the Karakorum mountains. The notes of every explorer who had visited these glaciers during the last hundred years were summarised in this paper (*Records, Geological Survey of India,* Vol. LXIII). The period during which these observations had been accumulated was, however, found to be too short to justify any definite conclusions.

(3) Montgomerie's Account of the Karakorum Glaciers in 1862.

In a lecture he gave in 1862, Colonel Montgomerie referred to several glaciers which he had seen in Baltistān in the course of his topographical surveys. His information has been supplemented by the more detailed observations of subsequent explorers, and his lecture is not now of scientific importance; but it was the first occasion on which certain Karakorum glaciers now well known were brought to notice. Montgomerie's discovery of the peak K^2, his long career as a triangulator at high altitudes in Kashmīr and Western Tibet and his early death have made him one of the heroes of Survey history, and his writings,—

the few in number that remain,—have still a traditional interest for his department. The following are extracts from his lecture :—

"*Karakorum Glaciers* : in the Braldu branch of the Shigar river there are "the Punmah glaciers, the Nobundi Sobundi glaciers, the Biafo glacier (33 miles), "and the Baltoro glacier, 36 miles in length,* with a breadth of from 1 to $2\frac{1}{2}$ miles. "Further west the Hoh valley produces a glacier (16 miles) and the Basha valley "contains the Kero (11 miles) and the Chogo (20 miles). The Braldu and Basha "valleys contain such a galaxy of glaciers as can be shown in no other part of the "globe except it be within the arctic circle. The Baltoro glacier takes its rise "from underneath K^2. All glacial phenomena are to be seen on a gigantic scale "in the valleys of the Shigar."

"An attempt was made to measure the thickness of the ice in the Baltoro "by sounding one of its yawning chasms, but a line of 160 feet in length failed to "reach bottom. Observations at the end of the glacier gave a thickness of 400 "feet, but higher up a still greater thickness will doubtless be found."

"In the Saltoro and Hushe river valleys round Masherbrum (Karakorum) "the most remarkable glaciers are the Shorpojong, 16 miles, the Koon-doos, "24 miles, the Nang, 14 miles, the Atosir, 11 miles."

"Of the Himālayan glaciers the Drung-drung, 15 miles, is the largest in "Suru ; the Brahma glacier in Wardwan is $11\frac{1}{2}$ miles long, the Purkutse in Suru "is $7\frac{1}{2}$ miles long. The Purkutse is perhaps the most remarkable of this Himā-"layan group, as it comes tumbling down in a torrent of broken pinnacles of ice "from near the summit of the Kun peak, 23,000 feet high ; it is a sight well worth "looking at ; though in actual length the Purkutse glacier is inferior to others, "it makes up for its want of length by the large mass of ice that is visible from one "spot."

(4) The Surveys of Kashmīr and the Karakorum in 1855-1865.

The surveys carried out in 1855-65 by the Survey of India were the highest mountain surveys that had ever been undertaken in any continent. In Kashmīr and Tibet the Government of India entrusted to the Survey no ordinary task, and Colonel Montgomerie was selected for the charge of the work. His previous survey work had lain in India, and he had had no experience of Alpine climbing ; his survey assistants were young military officers and civilians recruited in India ; none of them were mountaineers, and in those days of slow communications workers in India were less able to obtain European aid or advice than they can now. The valley of Kashmīr was of course well known, but the numerous valleys of Ladākh and Baltistān and the high fields of ice and snow were *terrae incognitae* ; there were no mountain roads, the hill-paths of the present day were mere primitive tracks, transport and provisions were most difficult to obtain. In ten years this small band of surveyors had completed an accurate

* The most recent values of length are Biafo 37 miles, and Baltoro 36 miles.

survey over the lofty regions with the exception of the highest areas of perpetual snow. The allotment of money sanctioned by the Government for this survey had necessarily been limited, and owing to the expense the highest portions of the glaciers and the highest areas of snow had to be omitted from the programme; but even in these areas Montgomerie and his assistants had determined the positions and heights of the peaks, now so well known as peak K², as Gasherbrum, and Masherbrum, and many others. These high land-marks fixed by Montgomerie have for 60 years been of service to scientific workers. A large portion of the area surveyed was higher than Mont Blanc and the glaciated area which he had to omit from his operations was less than one-tenth of the mountains surveyed. When in 1865 Colonel Montgomerie was given the gold medal of the Royal Geographical Society, the President said to him, "You have passed "from the hot plains of Hindostān to the loftiest region on the face of the globe, "and there amidst enormous glaciers you have made accurate scientific observations "at stations, one of which was 5,000 feet higher than Mont Blanc."

Colonel Godwin-Austen was Montgomerie's senior assistant: he was a skilled topographer and his natural scientific bent showed itself in his glaciological surveys and in his subsequent geological researches.

In 1871 Sir Clements Markham wrote, "Godwin-Austen sketched most difficult "ground with taste and skill, including the enormous glaciers of Little Tibet, one "of them 36 miles long." One of the most brilliant of Montgomerie's assistants was Lieut. Elliot Brownlow, who was killed at the siege of Lucknow. The Surveyor General wrote of him in 1859, "Brownlow's adventures and achieve-"ments in the snowy mountains, and his hardihood and endurance were the theme "of much praise amongst his brother surveyors. He had intended to devote his "rare and splendid qualities as a mountain surveyor to the exploration of Central "Asia."

Though Montgomerie's maps are now 67 years old, and are no longer abreast of modern standards, they have faithfully served many geologists, and many other scientific travellers, and they have been the treasured companions of generations of sportsmen. Montgomerie himself was the first observer of peak K²: his assistants subsequently helped him by supplementary observations from other stations to fix the peak accurately and to measure its height.

In 1871 Sir Clements Markham referring both to Kashmīr and Baltistān summed up the position, as it appeared to him then, in the following words: "The topographical survey of the Western Himālaya, conducted under Mont-"gomerie, the accounts of its glaciers by Godwin-Austen and the examination of "its southern portion by Medlicott have rendered our knowledge accurate and "complete."

In recent years a statement has been published that surveyors were ordered not to waste time on uninhabited districts, and it has even been represented that the Survey of India has regarded glaciological surveys as waste of time.

The Survey of India has surveyed many uninhabited districts. As a scientific department it has recognised the value of glacial surveys, and it does not consider such surveys as waste of time. But when a survey of mountains has been sanctioned at a certain estimate of cost, it is incumbent upon the surveyors to work within the estimate and to devote their time to the maps that are most urgently required for public purposes.

The difficulties of surveying the flanks and slopes of the snow-peaks, where the great glaciers have their sources, have prevented surveys from being attempted over the highest altitudes,—not only by the Survey but by the mountaineer-enthusiasts who have co-operated with the Survey.

When a survey party withdraws to its recess quarters after seven months in the field, its out-turn of field-work has to be compared against its cost in money. Surveyors hope to show a good out-turn, for it is only by good out-turns of work that future programmes become possible. A surveyor may have to climb day after day above 18,000 feet, as Colonel Tanner had to do in 1884 when he was observing the peaks of Api and Nampa ; at sunrise the sky was cloudless, but each day when he reached 18,000 feet, he found the peaks hidden by mists. There he sat idle with his *khalāsis ;* his theodolite was adjusted and ready, but the time of minimum refraction passed without the mist clearing ; he had been told that the observations were essential, but in despair he wrote to the Surveyor General that he was wasting his time. He did not say that glacial surveys were waste of time. It is still common to see in the reports of survey parties the laments of keen triangulators over the loss of their valuable time, when persistent mists have interfered with their mountain climbs up precipitous slopes. (A reference to this question is made in Chapter 20 of this book in connection with the survey of Nanda Devi).

The scale of survey adopted in the Karakorum.

When the surveys of 1855 were being planned, much consideration must have been given to the question of scale. The scale selected was that of 4 miles to one inch. Although some travellers would have preferred a larger scale, the majority of civil and military officers, sportsmen and scientists, have found the 4-mile maps useful and handy. If the Survey had adopted the scale of 1 mile to 1 inch, more details of hills could have been shown, but for each sheet of the existing map, there would have been 16 sheets of the one-mile map. In a mountainous country travellers require information to be concentrated ; they find it inconvenient to have to change sheets often especially in a wind ; and even in a hill-tent there is no room for spreading out sheets.

The method of representing mountains upon maps.

The method of representing the Himālaya upon maps must have been an extremely difficult question, when the new pioneer era of surveying was

opening in the Himālaya and the Karakorum. The representation of mountains upon paper has both a scientific and an artistic side; a beautiful map that emphasises salient features and gives a broad view is often preferred to the more accurate map, in which breadth of view has had to be sacrificed to complexity of detail. Many mountain students have come now to realise that the old engraved Himālayan and Karakorum maps on the 4-mile scale, published in 1865, represent a very high standard of draftsmanship and artistic power. The old vertical hachures are sometimes ridiculed as hairy caterpillars, but such ridicule is quite undeserved and short-sighted. Experienced sportsmen who have used the maps for years have expressed their preference for the old artistic sheets over the modern and more scientific styles. The new sheets have of course one great advantage over the old; the different colours on modern maps enable glacial details to be shown which were not possible in the days before colour printing had been invented.

It is interesting to read the opinions of the Director of Map Publication of the Survey of India offices in Calcutta in 1932, who was writing 70 years after Montgomerie's surveys of the Karakorum; he wrote: "The old 4-mile sheets "were drawn by highly skilled men and the vertical hachuring lent itself to artistic "expression. Our representation with horizontal contours is sometimes good but "sometimes not; horizontal form lines of uniform thickness at wide vertical "intervals are a poor substitute for vertical hachures. Herr Dyhrenfurth has "produced a magnificent map of Kānchenjunga on the scale of 1 : 100,000, and "we do not regard this as any usurping of our functions. A one-inch map of "the Himālayan crest-line is not on our programme."

In the long interim that has elapsed between the pioneer surveys of 1860 in the Karakorum and the modern surveys of our own time instrumental equipment has become lighter and more accurate, methods of observation have been improved, and the invention of colour printing has placed greater powers in the hands of the draftsman. But the representation of mountains upon maps is not a purely scientific question. The contour represents a scientific idea, but in the Higher Himālaya the contour is an hypothesis rather than a practical reality; the contoured map contains much useful scientific information, but it gives at times a rounded appearance to the hills, that is not in keeping with their precipitous nature.

The artistic side of the Himālayan problem cannot be overlooked. Scientific advances are always in progress, and surveyors have learnt that even their fundamental triangulation is liable to become out of date. But the drawing of the Himālayas is not a mathematical problem like the Figure of the Earth, and though mathematicians may teach us now that the theory of gravitation is out of date, artists continue to urge us to study the "old masters". Himālayan draftsmen are thus faced with the difficult task of combining the scientific requirements of modern times with the artistic ideas of the past.

(5) Sir Martin Conway, the first mountaineer-surveyor in the Karakorum.

Sir Martin Conway, now Lord Conway, was the pioneer of mountaineering in the Karakorum. In 1892, twenty-seven years after Montgomerie's surveys had been closed, Conway made surveys of the Hispar and Baltoro and other glaciers. Conway's contributions to the Karakorum maps were valuable, but his report showed a want of understanding of the Karakorum problem, and contained ungenerous criticisms of Montgomerie's survey maps. As Conway was the first mountaineer to use these maps, and as he advocated new methods of topography, his report has had an influence upon subsequent mountaineers.

Sir Martin Conway had had mountaineering experience in the Alps, and he had an admiration for certain Swiss maps. But he made the mistake of treating the Himālaya as though they were the Alps on a larger scale. The difference between them however is not so simple; an increase of height from 15,000 to 25,000 feet leads to rarefaction of air, lower temperatures, difficulties of food-supply, and it alters problems of surveying.

Conway claimed to be writing on behalf of geographers and mountain students, but he represented the views only of mountaineers who had used maps of the Alps.

He thought that a map of a mountain peak should help the mountaineer by showing him all its varying changes of slope, and should distinguish between the slopes which carried snow, and those that were bare rock, and those that were ice-covered. He told us that a mountaineer is more interested in information about the shape and the details of peaks and whether their faces are steep or gentle than in the accuracy with which their positions are fixed. "Now-a-days," he wrote, "when a range of mountains has to be surveyed, it is clearly "perceived that the form of the peaks must be shown." The upper regions of a glacier, he said, are of more importance than the lower.

When we recall the heroic attempts that experienced mountain climbers have made without success to climb Kānchenjunga and Mount Everest, we realise the unfairness of a map critic, who demands that the shape and details of peaks must be shown upon maps. How are surveyors to survey the shapes and details of peaks without ascending them with their survey instruments? And how are they to take instruments to summits which skilled mountaineers cannot climb? (See Chapter 20, Mr. Ruttledge on Nanda Devi).

To the topographer it is of greater importance to fix the positions and the heights of high peaks than to map rock details surrounding their summits, because many of these peaks are of interest to a world-wide public, and because they constitute the basic points upon which surveys are founded. Conway's principle was "details before accuracy", the Survey's principle is "accuracy before details".

When Conway wrote that the upper regions of a glacier are of more importance than the lower, he was overlooking the requirements of the geologists and the hill-people and sportsmen who frequently cross the lower glaciers, but who seldom climb to the highest regions.

To show the details of all high slopes, whether gentle or steep, whether snow or ice, would require a map on a large scale : the Survey of India map is on the scale of "4 miles to 1 inch". Sir Martin Conway began his own survey of a glacier on the larger scale of "2 miles to 1 inch", and during work he further enlarged his scale to "$1\frac{1}{4}$ miles" for the inclusion of more detail ; but he found this scale too large for work at high altitudes. Finally he decided that the Survey scale of "4 miles to one inch" would after all be best for the field-work. His own scales of work he proposed to enlarge in England to "1 inch to 1 mile" to include detail from photographs. Such an increase of scale indoors would mean an enlargement by 16 times of the 4-mile map as made on the spot. No topographer would make a detailed map by enlarging his outdoor work so enormously, and by adding the details indoors. It is true that such a map might make a charming picture, but in Baltistān it would not resemble the ground.

On the principle that details and shapes were more important than accuracy of positions Sir Martin Conway did not carry on a continuous triangulation, and "the various parts of his map had afterwards to be connected by the help "of points determined by the Survey of India."

Sir Martin Conway summarized his opinions in the following sentence : "From the Survey sheets a mountain student cannot learn much for the very "good reason that they were not constructed with a view to his enlightenment."

Did the eminent geologists Oldham, Lydekker, Stoliczka, and Drew receive no help from these maps ? Did Arthur Neve, the mountaineer, gain no enlightenment,—Neve who for years was basing researches upon these maps and who traced the Karakorum across Depsang ? Did Francke, the leading authority on the Bālti language, who resided for years at Khapalu, and who knew every village in Baltistān, gain no enlightenment,—Francke who studied the mountain names?

In 1932 the Director of Map Publication in Calcutta has explained that the programme of future work before the Survey of India does not include a "one-inch" survey of the Himālaya crest-line. It was the absence of such a survey in 1892 that led to Sir Martin Conway's complaints. Though Conway's topographical principles have not been adopted in India, the example he set of individual enterprise in surveying the glaciated regions has been followed by subsequent explorers, and the system he founded by which the Survey maps of the ice and snow can be supplemented by means of the sketches and surveys of scientific enthusiasts will in course of time lead to the production of a map of the higher regions of each glacier,—but not of the shapes and slopes and summits of the great peaks.

(6) THE SURVEYS OF THE WORKMANS.

In 1898-99 Mrs. Bullock-Workman and Dr. Hunter Workman commenced their long series of explorations and surveys in the Karakorum. The photographs they published in their books marked an advance in the art of geographical photography. The first surveys which they made were of the Chogo Lungma and Biafo glaciers.

In 1903 they climbed above 23,000 feet in the Karakorum, and in 1906 they climbed the high peak of Mer, (23,250 feet) one of the Nun Kun peaks in Suru. Their "camp America" in Suru (21,000 feet) was the highest point at which mountaineers had passed a night.

In 1908 they made surveys of many tributaries of the Hispar glacier and some observations of the Yengutsa.

In 1909 Dr. Longstaff had discovered that the pass at the head of the Bilafond glacier leads into the Siachen glacier, and in 1912 Mrs. Bullock-Workman went up the Bilafond glacier, and crossed the Bilafond La into Siachen. Dr. Peterkin who was a member of the Bullock-Workman expedition of 1912 made a survey of the Siachen glacier. This survey was a work of skill, and it was by no means the only geographical contribution to the unsurveyed ice-fields of Karakorum, for which the Survey of India has been indebted to the Bullock-Workman expeditions. These expeditions are in fact remembered as having helped to fill many gaps in the maps of the snows.*

(7) THE EXPLORATIONS OF DR. LONGSTAFF.

Dr. Longstaff has co-operated with the Survey of India as a mountain surveyor and as a successful explorer. In 1905 he climbed to a height estimated at 24,000 feet on the peak of Gurla Mandhāta, and he wrote the chapter on this mountain in Mr. Sherring's book on "*Western Tibet and the British Borderland.*" In 1908 he climbed to the summit of the peak of Trisūl (23,360 feet) in the Kumaun Himālaya. During his movements over Higher Kumaun he discovered an error in the representation of the Bagini glacier upon a map of the Survey. His subsequent explorations in the Karakorum have had valuable results, which will now be considered.

The Saltoro Pass.—The Saltoro river is a north-eastern tributary of the Shyok and it drains the Karakorum between Masherbrum and the Nubra. Its principal source is the Bilafond glacier. There had for many years been a tradition that an unused pass, known as the Saltoro pass, existed at the head of the Bilafond glacier across the main Karakorum range. Only two passes over the Karakorum range had been used by the people of Central Asia, the

* *Climbing and exploration in the Karakorum*, 1904.
Peaks and glaciers of Nun Kun, 1909.
Two summers in the Ice-wilds of Eastern Karakorum, 1908.

Karakorum and the Muztāgh. The Karakorum pass, east of the highest peaks is the best-known pass in Asia, and was in use by travellers between India and Turkistān before the dawn of history. The Muztāgh pass, west of the highest peaks and leading into Hunza, has been used by local inhabitants, but it is a more difficult pass than the Karakorum, and has never been a regular trading route. Between these two passes tradition had placed another pass, potential but not used, named the Saltoro pass. It is difficult to trace the origin of this tradition: Cunningham in 1850 did not allude to it: Henry Strachey whose studies of topography and nomenclature are as valuable to-day as they were in 1848, did not know the Saltoro pass; Drew did not mention it. The name "Saltoro pass" implied that the pass was at the head of the Saltoro valley, and tradition placed the head of the Saltoro valley on the main Karakorum watershed.

In 1889 Sir Francis Younghusband had climbed the Urdok glacier on the northern side of the Karakorum range and had actually reached the watershed, but had not crossed it. The depression in the range reached by Younghusband has since been known to mountaineers as "Younghusband's Saddle."

In June 1909 Dr. Longstaff accompanied by Dr. Neve and Captain Slingsby explored the Bilafond glacier: Longstaff found that this glacier was the largest glacier feeding the Saltoro river. "Had not Bilafond," he wrote, "been a "well-accepted local name this glacier might well have been termed the Saltoro "glacier, for tradition and usage have given the name Saltoro to the pass: but "locally the pass is called Bilafond La." The Survey of India attaches much weight to names that are in local use amongst inhabitants, and on Dr. Longstaff's authority the name Bilafond La was adopted for this pass. The name Bilafond La was subsequently confirmed by Mrs. Bullock-Workman as being in local use.

The Siachen glacier.—The Siachen glacier is the main source of the Nubra river, Moorcroft visited the upper Nubra valley in 1821, and Henry Strachey reached the lower part of the Siachen glacier in 1848. Montgomerie knew the Siachen glacier but he had never discovered that it had its source on the main Karakorum watershed.

In 1909 when Longstaff crossed the Bilafond La, he naturally believed that he was crossing the Karakorum watershed, and when he had begun to descend the new glacier on the further side he thought he had crossed the Central Asian divide. But he now made the surprising discovery that this glacier was not flowing north into Central Asia but south into the Nubra valley. His explorations showed that the new glacier must be an upper length, hitherto unsuspected, of the Siachen glacier and that the Siachen glacier must be 45 miles in length and the largest glacier in the Karakorum. It proved also that the main divide itself, which is the most important watershed in Asia, followed a more direct line than had been shown upon maps and that its supposed curve to the south

was an error. Longstaff's exploration also proved that "Younghusband's Saddle" was the divide between the Siachen glacier of Baltistān and the Urdok glacier of Shaksgam. This saddle was therefore not on the Saltoro watershed, and could not therefore be called the Saltoro Pass. The tradition which had placed the Saltoro pass on the main divide of Asia had therefore been in error, and its error had led to controversies over the name. The name Saltoro pass has not the importance that tradition had ascribed to it: it is only an alternative name for the pass in Baltistān known as the Bilafond.

The name Saltoro La is a tradition, deserving of record in history, but the name Bilafond La is a geographical truth. To future geologists, explorers and surveyors, a map will be of more use if it shows a name such as Bilafond La, which is a living name, than if it shows Saltoro La, which is a tradition known only to students of mountaineering history.

The question of a suitable name had to be considered for the pass over the Karakorum between the Siachen glacier on the south side and the Urdok glacier on the north. The name "Younghusband's Saddle" may be suitable on a mountaineering map prepared for mountaineers, but it is not suitable on a general topographical map, which is required to tell the Government and travellers the names most probably used by the inhabitants. It may be held that though the Karakorum divide is an important feature in geography, the pass across it from the Siachen to the Urdok had not been named by the inhabitants. When a case arises, in which geography has to lead the inhabitants instead of following them, as is its normal duty, the best course is to consider the local nomenclature and to attach to the pass a name already existing in the district. Dr. Longstaff found that the local district was called Teram, and he very rightly named the new peak which he discovered "Teram Kangri," *i.e.*, the snow mountain of Teram. Although as a mountaineer Dr. Longstaff has an historic regard for the English name Younghusband's Saddle, he thinks that as a Balti name should be shown on a Government map for the important Balti pass, the name Teram La would be most suitable. Dr. Longstaff writes: "This "is a potential pass,—possibly formerly used,—leading from Teram, the only "local name I found for the middle Siachen country. In the same way you "might call Dainelli's 'Colle Italia' between the Siachen and the Rimo glaciers "the Rimo La. Then on either side of Teram Kangri there would be Tibetan "names, Teram La and Rimo La."

Teram Kangri.—Dr. Longstaff's discoveries (firstly of the length of the Siachen glacier, secondly of the traditional Saltoro pass, thirdly of the southern approach to Teram La, and fourthly of the error in the Karakorum watershed line) were so unexpected as to border on romance; they would have been sufficient rewards for the most ambitious explorer. But Dr. Longstaff was a spoilt child of fortune, and he was yet able to make another notable discovery

in the shape of a new high peak that had hitherto been unknown but which is now known as Teram Kangri (24,489 feet). Montgomerie's chains of triangulation had been carried in 1860-65 all over Ladākh, and from every station his observers had shot all the peaks visible, but they had missed Teram Kangri: Teram Kangri had been hidden from them by nearer mountains.

"Perhaps in describing mountains," wrote John Ruskin in 'Modern Painters,' "with any effort to give some idea of their sublime forms, no expression "comes oftener to the lips than the word 'peak,' and yet it is curious, how rarely "even among the grandest ranges an instance can be found of a mountain ascertain- "ably peaked in the true sense of the word,—pointed at the top and sloping "steeply on all sides."

In Chapter 1, Part I, of this book we have attempted to give a list of the principal peaks of Himālaya and Tibet that are known to rise above 24,000 feet. But such a list cannot be compiled with real accuracy. A peak like Mount Everest (29,002 feet) has upon its slopes and buttresses hundreds of excrescences that rise above 24,000 feet, and all these might be included in a list. But such a list would be only a tedious catalogue and could never be complete. The list in Chapter 1, Part I, is intended to present a picture illustrating the mountains of Asia, and in such a picture a peak of 24,000 feet that is visible from distances on all sides is of more importance than a peak of 27,000 feet which is standing close to Mount Everest, and being hidden from view by its great neighbour is rarely visible against the sky-line from any distance. Trigonometrically a peak should be defined as follows :—"A peak is a pointed mountain summit "that is visible from many and opposite directions and from long distances, if "the view of it is not cut off by an intervening range." It is quite easy for a traveller at any time to discover new peaks of 24,000 feet on the slopes of Makālu or Dhaulāgiri or Nanda Devi or Nanga Parbat, but it is not easy now in the Himālaya or Karakorum to discover a new solitary peak, that is surpassing in height all its surroundings. The angle-books of the Survey abound in instances of high peaks being observed from one or even two stations, and then being rejected because they were not seen again.

No one can question the claims of Teram Kangri; it can be seen from the south and from the north; its isolation renders it a "peak" however we define the word. The position and height of Teram Kangri were determined by the Survey of India in 1911 at the request of Dr. Longstaff. The Survey observer was Mr. V. D. B. Collins who carried out a series of triangulation from Ladākh up to the Karakorum crest-line with great courage and skill. During this work he had to ascend 16 peaks of over 19,000 feet in height. Mr. Collins had joined the Survey of India at Dehra Dūn in 1904. In 1914 on the outbreak of the Great War, he was appointed a lieutenant in the 2nd Gurkhas: he was killed in action on May 9th, 1915. He had great qualities as a surveyor, and his death was much lamented by his department.

(8) The Surveys of Sir Filippo de Filippi.

In 1909 de Filippi accompanied the Duke of the Abruzzi's expedition to the Karakorum. The Duke's object was mountain climbing and he succeeded himself in attaining an altitude of 24,600 feet, the greatest height that had then been reached by man. De Filippi made useful surveys of the upper portions of the Baltoro and Biafo glaciers and of the main Karakorum range in the neighbourhood of K^2. (*Karakorum and Western Himālaya*, by Filippo de Filippi, London, 1912). In his book he has emphasised the necessity of regarding the Karakorum as a distinct and separate range from the Himālaya.

In 1913-14 de Filippi led an expedition through Ladākh and Baltistān and across the Karakorum to Turkistān ; his surveys on this expedition included a complete map of the Rimo glacier. (*Himālaya, Karakorum, and Eastern Turkistān*, by de Filippi, 1932). This glacier is the principal source of the Upper Shyok river, a feeder of the Indus, and Filippi showed that it is also a source of the Yārkand river, which flows northwards into Central Asia. Colonel H. Wood of the Survey of India accompanied de Filippi through Depsang and across the Karakorum pass ; an excellent map of the countries on both sides of the Karakorum pass was one of the many benefits that resulted from the expedition. A portion of this map for which de Filippi was responsible, was published by the Survey of India in 1922 in Colonel Wood's report, "Explorations in the Eastern Karakorum and Upper Yārkand Valley." (Narrative Report of the Survey of India's detachment with the de Filippi scientific expedition). The map and report illustrate an important region of the Karakorum, —important on account of the wide geographical and geological questions involved ; not only does the map illustrate the complex connection between the Survey of India's work in Higher Baltistān and Sven Hedin's work in Tibet, but it depicts also the geography of the main watershed of Central Asia, "the backbone of High Asia," at the place where it is crossed by the caravan route which has connected India and Turkistān for centuries. Colonel Wood's map and report will have also a sentimental and historic interest for the Survey of India ; not only do they bear witness to the constant harmony that existed between his detachment and the Italian expedition, but they were the last contributions to Tibetan geography which were made by Colonel Wood whose insight and gifts as a mountain-surveyor have served his department on many occasions of difficulty in the Himālaya, in Tibet and in the Karakorum.

(9) The Glacier-Surveys of Mr. and Mrs. Visser.

In 1925 Mr. and Mrs. Visser made valuable observations and surveys of many of the Karakorum glaciers. They were accompanied by Khan Sahib Afraz Gul Khan of the Survey of India, who had had previous experience in mountain-surveying. Mr. and Mrs. Visser have given .a complete account of the Batura glacier in Hunza. They surveyed the whole of the Pasu glacier and the snouts of the Hispar, Minapin, Hasanābād, and the Shingshāl Valley

glaciers. (*Among the Karakorum Glaciers*). On a more recent expedition they surveyed the lower Siachen.

(10) THE SHAKSGAM VALLEY.

The Shaksgam river is the upper portion of the Oprang and the most important tributary of the Yārkand river. It lies along the northern foot of the Balti-Karakorum and is fed by the northern glaciers of the Karakorum range, the Kyagar, the Urdok, the Gasherbrum, and others. It is an interesting longitudinal trough that only exists as a trough where the Karakorum range is very high. Further east, where the Karakorum loses its great height, its northern drainage like its southern, is transverse. The longitudinal troughs in which lie the Baltoro, Biafo and Hispar glaciers on the southern side of the Karakorum, have their counterpart in the longitudinal Shaksgam on the northern side. On both flanks of the high Karakorum range from K^2 to Teram Kangri, the drainage is longitudinal: further east and further west the drainage is transverse.

The first European to discover and cross the Shaksgam valley was Sir Francis Younghusband, when in 1887 he made a journey across the deserts of Chinese Turkistān to India. He reached the Shaksgam from Yārkand, and beyond it he saw the great Karakorum range. This range had always been crossed by Europeans and caravans further east at the Karakorum pass. Younghusband crossed the Shaksgam river, climbed up the glacier which was descending from the Muztāgh Pass, and crossed the pass itself. (*Geographical Journal*, December 1930, p. 522).

In 1889 Younghusband returned to the Shaksgam valley, and on this occasion he followed the course of the river. He discovered the Gasherbrum and Urdok glaciers, which were descending from the Karakorum crest to the Shaksgam. He actually climbed the whole length of the Urdok glacier to the depression in the crest-line. This was a remarkable exploration, which has led to considerable geographical enlightenment. Younghusband came to the conclusion that there was no "pass" across the Karakorum from the Urdok glacier into the drainage basin of the Nubra. (*The Heart of a Continent*). By pass he meant a "real pass", that is a "passable pass"; but he did find at the head of the Urdok that the high Karakorum crest-line dipped here almost to 19,000 feet: this dip has been known to mountaineers as "Younghusband's Saddle". In 1909, twenty years after Younghusband's discovery of the depression in the range, Dr. Longstaff explored the same depression from the south. He found that this depression was on the divide between the Urdok and Siachen glaciers, that is between the drainage systems of the Shaksgam and Nubra rivers. As already mentioned in this chapter, Dr. Longstaff has described Younghusband's Saddle as a "potential pass" and he has suggested that the best Balti name for this potential pass would be Teram La, a suggestion that may well be accepted.

In 1926 the expedition under Major K. Mason made surveys of the upper Shaksgam and its sources. Mason also surveyed the Aghil mountains north of the Shaksgam. (*Records, Survey of India,* XXII, 1928. *Exploration of Shaksgam Valley*). His surveys were connected on the east with those of Filippi and Wood, and they mapped the barren rocky country that lies north of the Balti-Karakorum. Wood's and Mason's surveys proved that the idea of a long Aghil range ranking in importance with the great ranges of Tibet was fallacious: this range had received its name from the Aghil pass, but Mason's survey showed that the Aghil pass was a pass crossing a secondary range or ridge. The peaks of this ridge are undoubtedly high, rising in places above 21,000 and 22,000 feet, but they belong to the flank of a great range, which rises itself to 26,000 feet and 28,000 feet. The Shaksgam trough separates the Aghil ridge from the Karakorum crest in the same way as the Baltoro trough on the southern flank of the Karakorum separates the Masherbrum ridge from the main crest.

(11) Professor Dainelli's expedition, 1930.

Professor Dainelli's success in 1930 in discovering a pass between the Siachen and Rimo glaciers was due to his geographical insight; his study of maps had convinced him that there must be a topographical mistake, and when after great perseverance he had surmounted the ice and snow, he saw what the mistake was, and how it had arisen. This valuable discovery, and the way it was brought about, are object-lessons for future explorers.

Professor Dainelli has given the name "Colle Italia" to the pass between the Rimo and Siachen glaciers in remembrance of the contributions which his fellow citizens have made to Karakorum geography. The caravan led by Dainelli was the first European caravan to cross this pass. If the geographical nomenclature of Tibet is to be designed as a monument of European achievements, the name "Colle Italia" will certainly deserve a place of honour, but if a nomenclature is to be evolved that will be agreeable and comprehensible to the Balti people, when their geographical education progresses, the name "Rimo La" will be more suitable than Colle Italia. Dainelli himself has proved that in a former age the Baltis used to cross the Rimo La on their journeys to Yārkand.

Professor Dainelli's Roman forefathers ruled in Britain for 400 years. They governed the Britons with an iron hand, but they introduced a system of nomenclature that we might do well to follow in Asia. When they built a town such as Londinium, or a fortress such as Chester, or when they fortified a city like Winchester, they gave it a Roman name; they gave Roman names to works of their own creation, but they allowed the Britons and Welsh and Scots to name mountain features. We value and preserve Hadrian's Wall, but we have no Mount Agricola and no Colle Romana.

(12) THE VIEWS OF MILITARY OFFICERS EXPERIENCED IN HIMĀLAYAN TRAVEL.

The following quotations are from General Bruce's book, '*Twenty years in the Himālaya*':

"My object," he writes, "is to try and show the great contrasts between "people, country, life, etc. that exist in the different districts, from the Kāfir border "on the west to the Bhutān border on the east. Between these extremities "probably no greater contrasts could be found on the world's surface. The "Highlands of Scotland and Southern Italy do not present greater contrasts."

"To the keenest climber mountaineering in these great ranges is more of "the character of mountain travel than of a climbing expedition, such as could "be planned in Switzerland, and at present it must be so, unless the traveller "is content to march direct to some group and stay there. But few travellers "are so content, as there is so much new country to be seen, and all the surround- "ings are of such interest that the time for climbing particular peaks has not "yet arrived."

"In the summer of 1898, some two months after the retiring of the troops "from the different expeditions .... in the North-West Frontier of India ".... I arranged .... to take with me a few men from several Gurkha "regiments, my idea being that practice in mountaineering, or rather mountain "exploration, is one of the finest educations for an infantry or hill scout. ".... His training as a path-finder alone is worth anything to him; and in "the .... Himālaya this training can be obtained in a way that can probably "not be matched in any other part of the world. However good the maps "may be—and in general the India Survey maps .... are astonishingly good "—one is thrown quite on one's own resources ...."

"Further, men trained in really difficult country will, when they have to "work in much easier country, do so with confidence and certainty."

These were the views of General Bruce, and the following quotations are from a note on Himālayan maps by Colonel P. Neame, V. C.:

"This note is intended to apply to those mountain regions on the north and north-east frontiers of India which include the Karakorum and the various ranges of the Himālaya, the Ladākh, Zāskār, Great Himālaya, etc. It is not intended to apply to the regions of the North-West Frontier for which special military maps are often required.

"In arriving at the type of map required one must consider principally the users of the map. The man who is going to use the map on the mountains is the customer of the Survey of India, for if no maps are sold none need be printed, and mere record plans on any scale suitable might be filed for use in Government offices. It is safe to say that the traveller or sportsman is the principal user. A few British and Indian officials will require maps for official use.

"The traveller or sportsman will normally be travelling several or even many hundreds of miles in a few months. A large bulk of maps must be avoided for much baggage is a hindrance. He requires to find his way along the main routes from camping ground to camping ground, or village to village, and at intervals into branch *nālas* or over little known passes from one *nāla* to

another. In these regions the details to be mapped that concern human occupation are few, the shape of the ground and the natural features such as streams and rivers are of all importance. A few place names are of importance.

"The map on the scale of one million shews the general lie of the country, the big features and main rivers, and main routes, but is entirely inadequate in detail for the traveller. The '4 miles to 1 inch' sheets (approximately 1/250,000) in my opinion are the most suitable maps for the large majority of the map users of these regions. In my experience, ranging from the Garhwāl Himālaya in the east to Gilgit and the Hindu Kush in the west, these maps show, although the survey was done many decades ago, the shape of the country with extraordinary accuracy. In the most remote *nālas* I have never found myself let down by them. They show or could show all necessary routes and place names and villages. I would be prepared to accept a smaller scale, 6 or 8 miles to the inch, but I fear that the necessary detail could not be inserted. A larger scale, say 2 miles to the inch would be delightful to use in any particular *nāla* but in these regions there is little detail to show which cannot be shewn on the 4 miles to one inch scale, and the bulk of maps to be carried would be quite prohibitive.

"There is one more class of user to mention, and that is the mountaineer, but he must always form a very small percentage of the customers of the Survey of India. Doubtless he would like a larger scale map of the particular area he is going to climb in, but the Survey of India cannot tell from year to year what new ventures in this line will arise, and obviously the supply of large scale contoured maps of all the well known glaciers and peaks is impossible even by the efficient machinery of the Indian Survey Department.

"I am therefore of opinion that the choice of the scale of 4 miles to 1 inch made over seventy years ago for the topographical maps of regions such as Ladākh and Baltistān, still meets the requirements of the majority of mountain travellers.

"There are a few aspects in which these map sheets might be improved, if a revision or re-survey is ever undertaken. Although as I have said, I found the topographical features very accurate, I often found extraordinary lapses in the positions and names of villages and camping grounds. This applies to some extent in Ladākh and Gilgit, but above all other areas in Tehri Garhwāl, where I found the place names on the main pilgrim route up the Bhāgīrathi valley to Gangotri, completely at variance with facts. It was impossible to locate or identify quite 50 per cent. of the names on the map, a few of the real villages or camping grounds were placed on the map. And this is not due to any changes in this area since the maps were made, because I have followed my route stage by stage in a very old Himālayan *Shikār* book written in the eighteen forties, and the names of villages, *nālas*, and camping ground given there are identical at this day.*

"One other comment, spot levels do not always seem very accurate although the general shape of the ground does appear accurate. But as I have only been able to check these by

* Colonel Neame's references to "extraordinary lapses in the positions and names of villages and camping grounds" are very puzzling. It is out of the question to suppose that the experienced surveyors of Garhwāl made gross mistakes in nomenclature or in fixing villages. The errors discovered by Colonel Neame do not refer to mountain features or to river junctions or river bends: they refer only to human habitations. The only explanation seems to be that in 1872, when the surveys were made, the villages had been moved from the positions they had occupied in 1842, when the old *Shikār* books were written; and that in more recent times they have been moved back to the original positions of 1842. If villages are destroyed by an earthquake, the surviving villagers may be driven by terror to erect their habitations in new spots, and if villages are devastated by plague or cholera, the hill-people may be forced to forsake them and to erect new villages on new sites. But the original sites are sure to possess natural advantages. and the people will be led to return to them when after a lapse of years the cause of the migration has faded from memory. S. G. B.

aneroid I would not be certain. But I remember finding anomalies on the slopes of Haramosh—differences in height checked during one morning or one day of unchanged weather, which no drop of the aneroid would account for.

"I think I have said enough to show that the existing 4 miles to 1 inch sheets are of great value and most suitable to the bulk of the travellers who are map users in these regions."

(13) The recent Glacier-Surveys of the Hindu Kush.

Among the most extensive glacier surveys that have yet been made in Asia, are those which were carried out by 'A' Survey Company, under Colonel Lewis of the Survey of India, in the Hindu Kush in the years 1928-30. The watershed of the Hindu Kush is the boundary between India and Afghānistān, and this boundary has always been of political importance. This survey was not a hasty reconnaissance, but a systematic extension of regular topographical survey over the snow- and ice-bound ranges which enclose the valley of Chitrāl, in a manner never previously attempted in the Himālaya.

In the *General Report, Survey of India* for 1928-29, the Surveyor General, Brigadier R. H. Thomas, referred to the completion of the survey of Chitrāl as a notable event of the year. "The survey," he wrote, "required careful "organisation and considerable enterprise; officers and surveyors with no pre-"vious experience of high climbing have triangulated and surveyed mountainous "and glaciated areas involving regular climbing to well over 18,000 feet." Several of the triangulation stations are above 19,000 feet. The total length of large glaciers surveyed may be estimated at 1,100 miles, and these formed only half the total glacier surveys (see Chapter 25 of this book). That the Hindu Kush glaciers are shorter than those of the Karakorum is probably due to the greater river-erosion, which has led to a multiplicity of valleys. In the course of this survey, Colonel Lewis instructed his surveyors in the recognition and delineation of glacier and mountain forms, and thus introduced a vast improvement into Indian methods of survey and mapping of high mountains. Earlier surveyors in India, working as a rule on a smaller scale, had shewn glaciers by an arbitrary symbol, and mountain sides by a conventional symbol for precipice, with no distinction between rock and snow features.

The pioneer surveyors in these regions, Tanner between 1878 and 1882, and Woodthorpe (1885-86), and various Indian explorers about the same period, worked under great difficulties; the inhabitants were unsettled and jealous of intrusion, so that access was not everywhere possible; the surveys were really hurried geographical reconnaissance, filling in the vast blank spaces on the maps of those days.

CHAPTER 19.

THE HIMĀLAYAN RIVERS.

The mountain features which first attract the interest of travellers are the high peaks, and from observations of peaks geographers deduce the alignments of mountain ranges. In Part III of this book the Himālayan drainage is described. As the drainage has resulted from the ranges, and as the rivers have their sources in the ranges, a certain amount of repetition from Parts I and II is unavoidable in Part III. When we come to consider the drainage, the long alignments of peaks are lost sight of; we now divide the Himālayas into compact riverain areas, which lie across the main chain and not along it. The mountains are identical with those of Parts I and II, but we are now regarding them more from the point of view of width than of length.

The Evolution of River names.—If the references to Indian rivers are traced from ancient to modern literature, the changes which their geographical names have undergone become apparent. Such changes have been due mainly to the different pronunciations which have been in vogue at different epochs. The Greek Empire in India is sometimes criticised for having carelessly corrupted the geographical names, but there is little foundation for this complaint. The Greeks named the Himālaya the "Emaus"; the early forms of Himālaya were Hima, Himāl, and Himāchal. The name Himāl is in common use on modern maps of the Nepāl snows. The Greek word Emaus is a form of Hima.

The earliest forms of the river names are to be found in Vedic and Sanskrit literature, and they date from 2,000 B. C. or earlier. The Greek Empire was founded in India by Alexander in 327 B.C., but its historian Arrian did not write his history till 140 A.D. Megasthenes the Greek traveller was living at Pātaliputra (Patna) in 300 B.C.; he made valuable records, but they have been lost, and we know of them only through Arrian's and Strabo's quotations. Pliny the Roman naturalist wrote his treatise about 70 A.D., and Ptolemy the Egyptian whose name is associated with his theory of the Solar system, drew his map of the world in 150 A.D.

Modern geography has been blamed for corrupting the ancient name Ganga into Ganges. But Megasthenes who lived on the Ganges in Bengal in 300 B.C. is said to have applied that name to the river Ganga, and Strabo and Ptolemy used it also. Modern geography is therefore not responsible for the variation from Ganga to Ganges.

River names of the plains.—In some cases a name has been given to a river in the plains by people living on its banks, and another name has been given to the mountain section of the same river by the people living in the mountains. Thus the name Indus originated in the plains of the Punjab, but in Ladākh the same river was named Sinh-Kha-Bab.* Although the Ladākhis

* Sinh-Kha-Bab (Moorcroft, 1820).
Singi-Tsangpo (Sven Hedin, 1908).

do not know the name Indus, modern geographers have extended this name through Ladākh, because it has been proved that the river of Ladākh is the upper course of the Indus. An old Survey of India map shows that the Surveyor General (Rennell) in 1788 was unaware of the course of the Indus through Ladākh: he knew well that this great river must rise behind the Himālaya but he placed its source by conjecture at Kāshgar. He was under the belief that the river of Ladākh flowed into the Ganges.

The name Brahmaputra originated in the plains of Bengal and its identity with the Tsangpo of Tibet was only established in 1884. The name Indus had been extended into Ladākh about 1850, but between 1850 and 1884 views upon nomenclature had been undergoing a change, and the name Brahmaputra has not been allowed to supersede in Tibet the Tibetan name Tsangpo. In 1850 the surprising discovery that the Indus had its source near Kailās was emphasized in the nomenclature on maps, and its Ladākhi name was given a secondary place: but in the present day the preservation of the Tibetan name Tsangpo is considered of primary importance, and the identity of the Tsangpo with the Brahmaputra is shown only in the drawing of the river's course.

The name Jhelum originated in the plains, and has been extended into Kashmīr, probably during the Mughal Empire but the village people of Kashmīr still use the older name Behat.

The names Sutlej, Chenāb and Gogra, all well-known in the plains are not Himālayan names. The names Rāvi, Beās and Jumna have spread into the mountains from the plains. The largest Himālayan branch of the Jumna has been given the Himālayan name of Tons.

Table showing the historical variations in the geographical names of the Rivers of Northern India.

Names in use 1932 A.D.		Vedic 2,500 B.C.	Sanskrit 1.500 B.C.	Greek 300 B.C. to 140 A.D.	Ptolemy 150 A.D.
In the Plains.	In the Himālaya.				
Indus.	Indus.	Sindhu.	Sindhu.	Indus.	Indus.
Jhelum.	Behat.	Vitasta.	Vitasta.	Hydaspes.	Bidaspes.
Chenāb.	Chandra Bhāga.	Asikni.	Chandra Bhāga.	Akesinos.* Acesines.	
Rāvi.	Rāvi.	Parushni.	Irāvati.	Hydraotes.	
Beās.	Beās.	Arji-kiya.	Viyās. Vipāsa.	Hyphasis.	
Sutlej.	Sutluda.	Sutudri.	Shatadru.		Zaradros.
Jumna.	Jumna.	Yamuna.	Jamuna.	Jobares. Jomanes.	Diamouna.
Ganges. Ganga.	Ganga. Alaknanda. Bhāgīrathi.	Ganga.	Ganga. Alakananda. Bhāgīrathi	Ganges.	Ganges
Gogra.	Karnāli. Kauriāla.				
Gandak.	Sapt-Gandaki.		Sadanira.	Khondocates.	
Nārāyani.	Salgrāmi.				
Kosi.	Sapt-Kosi.		Kausiki.		
Tīsta.	Tīsta.		Trishna.		

* Akesinos was the Greek name for the Asikni, which was the Chenāb of the plains: but Sandabal was the Greek name for the Chandra Bhāga of the mountains.

THE PRINCIPAL RIVERS.

The Himālaya mountains from Afghānistān to Burma are drained by twenty-two principal rivers, the drainage areas of which are illustrated in Charts XXIV to XXXIV. Chart XXIII furnishes an index to the several river charts. Eight section lines have been drawn across the index chart: they indicate the positions of the cross-sections of the Great Himālaya and, if scrutinised, they will be found to explain the positions given to the different Tibetan troughs in the cross-sections.

In the following table we have divided the Himālayan rivers into six orders of magnitude, classifying them by the dimensions of the mountainous areas they drain.

TABLE XIV.—The Rivers of the Himālaya.

Name of River.	Order of magnitude.	Himālayan area included in the catchment basin.	Total discharge of water in one year (estimated).*	Ratio of discharge to area, taking that of the Rāvi to be unity.
		Square miles.		
Indus	First	103,800	9	0·3
Brahmaputra	First	99,200	15	0·5
Kosi	Second	23,900	8	1·1
Karnāli	Second	20,600	8	1·1
Sutlej	Second	18,500	3·5	0·6
Gandak	Third	14,600	7	1·4
Jhelum	Third	13,000	5·5	1·3
Manās	Third	12,000	unknown	..
Chenāb	Fourth	10,500	5·5	1·6
Raidāk-Sankosh	Fourth	10,200	unknown	..
Ganges	Fourth	8,900	5·5	1·6
Luhit†	Fourth	8,000	unknown	..
Subansiri†	Fifth	7,000	unknown	..
Kāli	Fifth	6,300	4	2·0
Beās	Fifth	5,600	2·5	1·3
Dibāng †	Fifth	5,000	unknown	..
Tīsta	Fifth	4,800	3	1·9
Jumna	Fifth	4,500	2	1·3
Rāvi	Sixth	3,100	1	1·0
Rāpti	Sixth	3,000	..	..
Rāmganga	Sixth	2,600	..	..
Bāghmati	Sixth	1,500	..	..

The discharges of Himālayan rivers have not been sufficiently observed to justify any close study of the results obtained. The discharges of the smaller rivers vary from nothing at all in the hot season to thousands of cubic feet per second in the rains; their beds may remain dry for months, and be flooded

* The numbers in this column do not represent any actual units of measure. The total discharge of the river Rāvi has been taken as unity; and the numbers opposite the other rivers show the ratios of their discharges to that of the Rāvi. These numbers, it must be noted, are almost all dependent on short observations and rough estimates.

† Tributaries of the Brahmaputra that join the latter in the plains.

for a few days in the year. It is not possible under such circumstances to deduce any average values of daily or monthly discharges. The discharges of the larger rivers that have sources in glaciers never cease entirely, but their variations are sufficiently large to render averages meaningless. The discharge of the Indus will vary from 9,000 cubic feet a second to a million, and in almost all the Himālayan rivers the maximum discharge is 100 times as great as the minimum.

The classification of the rivers.

The Great Himālayan range is 1,500 miles in length: its long alignment passes through many varied regions, differing in their topography and their ethnology. In Chapter I, Part I, it was necessary to divide the long Himālayan alignment into regional sections in order to facilitate the classification of its high peaks. To group all the peaks as Himālayan was not sufficiently distinctive.

The Himālayas are divided by their people and by travellers into numerous sections, such as Sikkim Himālaya, Kashmīr Himālaya, Bhutān Himālaya, Garhwāl Himālaya, and many others. But it would not be in the interests of geography to adopt all these minor sub-divisions for the classification of peaks. In 1907 we came to the conclusion that the sub-division of the Great Himālaya range into four sections would be convenient and helpful, and as during 25 years this sub-division has met with approval, it is being continued now. The sub-divisions accepted in 1907, were as follows:—

Assam Himālaya, from the Brahmaputra to the Tīsta, 450 miles.
Nepāl Himālaya, from the Tīsta to the Kāli, 500 miles.
Kumaun Himālaya, from the Kāli to the Sutlej, 200 miles.
Punjab Himālaya, from the Sutlej to the Indus, 350 miles.

As the aim was to classify the Himālayan peaks into regional groups, we could not end the several sub-divisions at actual peaks, and we had to adopt the lines of river gorges, (cutting across the great range) as the boundary lines of the sub-divisions. The rivers that we selected to be the dividing lines of the range were the Tīsta, the Kāli and the Sutlej. East and west of the Tīsta the Himālayas exhibit ethnological differences; the nomenclature is also different, and the history of geographical exploration has been different. Thus the Tīsta formed a suitable boundary for the classification of peaks, and was accepted as the dividing line between the Assam and Nepāl Himālayas. But when at a subsequent stage it became necessary to adopt the same system of classification for the Himālayan rivers, the question had to be considered whether the Tīsta itself should be classed with the rivers of Assam or with those of Nepāl. The valley of the Tīsta forms the country of Sikkim, and its population is mixed: to the east of it lives the purely Mongolian population of Bhutān and to the

west the Aryan people are dominant. The Brahmaputra is the great river of Assam, and all the rivers of the Assam Himālaya flow into the Brahmaputra. The Tīsta also flows into the Brahmaputra, but the rivers of Nepāl flow into the Ganges. For these reasons it has been thought permissible to classify the Tīsta with the rivers of the Assam Himālaya, although it does not actually enter Assam. The river Kāli is the boundary between Nepāl and Kumaun; it has been classified with the rivers of the Kumaun Himālaya because its principal glacial sources are in Kumaun. The river Sutlej is the boundary between the Kumaun and Punjab Himālaya: it is also the ethnographic boundary between the Garhwāli and Dogra peoples. The Sutlej is essentially a river of the Punjab, and it has therefore been classified with the rivers of the Punjab Himālaya.

In the following descriptions of the rivers of the Himālaya we might have commenced at either end of the range and taken the rivers in their geographical order. But students of geographical history find that their conceptions of the Himālaya have extended from the centre outwards and not from end to end. The alluvial plains of India extend along the base of the Himālaya throughout their whole length from east to west, and their highest region exceeding 900 feet is between the Jumna and Sutlej. In 3,000 B.C. the only habitable part of these alluvial plains was the Ambāla-Patiāla area which was then watered by the Vedic river Saraswati, but which is now on the flat water-parting between the Jumna and the Sutlej. The first city built in the plains of India was Hastināpur on the Ganges, 2,000 B.C., and some centuries later Ayodhya was built on the Gogra (Ferguson's *Indian Architecture*). The first valleys of the Himālayas to be explored by the Aryan people were those of the Ganges and Jumna, and these were the first valleys also to attract subsequently the interest of scientific geographers. Even at the present time the eastern and western extremities of the Himālaya are not nearly so well-known as the central portion. Many of the Himālayan tributaries of the Brahmaputra are still unexplored, and the basin of the Indus still presents unsolved problems. By commencing in the centre of the Himālaya and by taking the rivers in their outward geographical order we start from the historic Saraswati watershed and move in both directions from the known towards the unknown.

By this arrangement the river Jumna comes first (see Chart XXIII) and the Ganges second, and when the Brahmaputra has been reached, we return to the Sutlej and we end with the Indus.

A separate chart has been drawn to illustrate the Himālayan area drained by each of the principal rivers (see Charts XXIV to XXXIV). Streams have been shown in light blue, and boundaries of basins in heavy black lines: the ranges being facts of deduction rather than of observation, have not been entered, but the highest peaks in each river basin have been plotted. and these indicate the alignments of main axes of elevation.

The thick lines, representing the basin boundaries, are water-partings but not necessarily mountain ranges: the line, for instance, in Chart XXXI between the Sutlej and the Karnāli crosses a flat plain in Tibet, and that between the Ganges and Jumna in Chart XXIV is in nature not a significant feature.

The forms of the river basins.

It is interesting to compare the Himālayan rivers with reference to the forms of their drainage basins:—

(1) The Brahmaputra and Indus are Trans-Himālayan rivers rather than Himālayan, and their respective basins embrace external areas of Tibet, Burma and Afghānistān. (Charts XXX and XXXIV).

(2) The larger rivers of Kumaun and Nepāl, namely the Jumna, Ganges, Kāli, Karnāli, Gandak and Kosi, all of which have glacial sources in the Great Himālaya have shown a tendency to flow in the first instance in directions at right angles to the snowy range, and subsequently to converge into great rivers before they enter the plains. (Charts XXIV to XXVIII). The perpendicular direction at first assumed has been due to the influence of the great range, and the subsequent convergence has been caused by the presence of a long continuous range of the Lesser Himālaya, which runs generally parallel to the snowy range and which blocks the rivers after their first descents. The alignment of this Lesser range will be considered in the subsequent chapters on the rivers, numbered 20, 21 and 22.

(3) The three small rivers of Kumaun and Nepāl, the Rāmganga, Rāpti, Bāghmati all drain small triangular outer basins, which have arisen owing to the convergence of the larger rivers.

(4) The forms of the basins of the five rivers of the Punjab Himālaya are unlike those of the Kumaun and Nepāl Himālaya, in that they are asymmetrical and oblique to the Great Himālayan alignment.* This difference in character is due to the fact that in the Punjab Himālaya the alignments of the Lesser ranges are oblique to the Great range whereas in Kumaun and Nepāl (and possibly Assam) the lesser range runs parallel to the great range. This lesser range known as the Mussoorie range in Garhwāl corresponds to the Mahābhārat range in Nepāl, but the actual continuation of the one by the other has not yet been proved.

* The obliquity of the Jhelum is not so obvious as that of the Chenāb, Rāvi, Beās and Sutlej; this is because it has been reinforced by the Kishanganga and Kunhar at the NW. termination of the great range.

CHAPTER 20.

THE RIVERS OF THE KUMAUN HIMĀLAYA.

The principal rivers of the Kumaun Himālaya are the Jumna, the Ganges, the Rāmganga and the Kāli.

The expression Kumaun Himālaya is a general term employed in classification, and it covers the Himālayan regions of Kumaun and Garhwāl. The river Kāli collects the drainage of Higher Kumaun, the Alaknanda drains British Garhwāl, and the Bhāgīrathi and Jumna drain the snows of Tehri Garhwāl.

THE JUMNA (Chart XXIV).

In the plains the Jumna is known as the river of Delhi and of Agra, in the mountains the Garhwālis know it as the river of Jumnotri and Bandarpūnch. Its Sanskrit name was Jamuna.

In the Vedas the Sapta-Sindhavas (the seven branches of the Ganges) were named as follows:—Ganga, Yamuna, Sarasvati, Sutudri, Marud-Vridha, Argi-Kiya, Parushni. The Jumna (Chart XXIV) is now draining a portion of the area formerly ascribed to the Sarasvati of the Vedas. A small river, still known as the Saraswati, flows across the alluvial plains at Thānesar some 20 miles west of the Jumna. The Saraswati glacier is one of the sources of the Ganges (Vishnuganga).

The highest sources of the Jumna are on the south-western slopes of Bandarpūnch, an imposing double peak which is visible from Mussoorie and Sahāranpur and which is illustrated in a picture in Part I. Bandarpūnch is on the watershed between the Jumna and Ganges, and near its base is the sacred shrine of Jumnotri, past which the Jumna flows.

Many prilgrims visit the shrine of Jumnotri every summer, but they avoid the gorges of the Jumna in the outer Himālaya, and they reach Jumnotri by ascending the Bhāgīrathi branch of the Ganges to the village of Dharasu,* and by then crossing the Ganges watershed into the upper Jumna valley; by taking this course they reach the Jumna 30 miles below Jumnotri.

In rear of the Mussoorie range (Lesser Himālaya) the Jumna is joined by its tributary the Tons, a tributary larger than itself: the combined rivers under the name of Jumna pierce the Mussoorie range immediately below their point of junction.

At the foot of the Garhwāl Himālaya there is a longitudinal trough separating the Himālayas from the Siwālik range. From the Jumna to the Ganges this trough is known as the Dehra Dūn, and on the Punjab side of the Jumna

* Shown as Than on Survey sheet 1/M 53. See Colonel Neame's note in Chapter 18 on the change in names of villages on the Bhāgīrathi.

the trough is known as the Kiarda Dūn. From the Dehra Dūn the Jumna receives its tributary the Asan, and from the Kiarda Dūn it receives its important tributary the Giri, which separates Simla from the Chaur peak.

On debouching from the mountains the Jumna sweeps round to the south-east, but in former times it is believed to have pursued a westerly course to the Arabian Sea (*Manual of the Geology of India,* page 450). The change in its course may have been caused by the gradual advance of the sands of the Rājputāna desert under the influence of the south-west winds.

The Ganges (Chart XXIV).

The Ganges (Chart XXIV) is the great river of northern India that drains the Vindhya mountains and the Kumaun and Nepāl Himālaya, and that waters the plains of Rohilkhand, Oudh and Bengal. Regarded as a Himālayan river, the name Ganges is applied to the particular affluent that issues from the mountains at Hardwār.

The Himālayan basin of the Ganges had been explored by the Aryan people many centuries before the Christian era. They named the river the "Ganga," and regarded it as Himavant's daughter, Himavant being the Himālaya range south of Kailās (*Vāyu Purāna and Mahābhārata*). The two main Himālayan branches of the Ganga were named the Alaknanda and the Bhāgīrathi, the latter name being derived from King Bhagīrath. In the Rāmāyana the river Ganga the wife of Sumudra, is described as "pure and removing sin." The Ganges is now the most sacred river of India; the Nerbudda is also sacred, but not to the same degree.

In no other region of the Himālaya have the mountain features been given so poetic a nomenclature as in the basin of the Ganges; in no other region has such a valuable legacy of geographical names been handed down from so distant a past. These names furnish an unique example of ancient geographical art, an example that modern geography has admired and perhaps even envied.

The source of a mountain river is the place where the glacier melts into water; it is the place where water issues. The Ganges has innumerable sources, of which all the most important have been known for centuries. In their writings to the press modern travellers occasionally fail to recognise the debt that will always be owing to the first Aryan explorers; for those early pioneers must have endured great hardships. The Himālaya mountains were standing between them and the sources of the Ganges; explorers had only two courses open to them; they had either to climb over the snows of the Himālayan crest, or they had to pass through long narrow gorges of rock, through which torrents were raging. Their dangers and their deaths inspired the poetry of their nomenclature.

When the sources of the river had been discovered, they became goals of pilgrimage; and though these sacred shrines can now be reached by good hill

roads, the great altitudes at which they are situated could in former centuries only be attained by mountain-climbing.

The Sanskrit word Prayāg is used by the Hindus to denote the junction of two rivers. The city of Allahābād which stands at the junction of the Ganges and Jumna is known to the Hindus as Prayāg. The termination Prayāg is frequently employed in the Gangetic Himālaya; the junction of the Alaknanda and Bhāgīrathi is known as Deo-prayāg, the junction of the Alaknanda and Mandakini on the southern slope of Kedārnāth and Badrīnāth is Rudra-prayāg, the Alaknanda's junction with Pindar on the southern slope of Nanda Devi and Trisūl is Karna-prayāg, and its junction with the Nandakna on the western slope of Trisūl is Nanda-prayāg. Vishnu-prayāg is a name applied to Joshīmath the junction of the Vishnu and Dhauli. The affix prayāg is not heard in Nepāl.

It was believed by Rennell, who was Surveyor General of Bengal in 1763-82, that the Ganges had a course, 800 miles long, above Hardwār, and that it drained Kashmīr and Ladākh: and these views were represented in his map of India published in 1790. He also thought that the Ganges after draining Tibet passed under the Himālaya through a natural tunnel. "This great body "of water," he wrote, "forces a passage through the ridge of Mount Himālaya, "and sapping its very foundations rushes through a cavern and precipitates itself "into a vast basin which it has worn in the rock at the hither foot of the "mountains."

Rennell was relying upon the descriptions given to him by travellers: what he thought was a cavern under the Himālaya was the ice-cave Gau Mukh at the end of the Gangotri glacier, from which the Bhāgīrathi issues.

By 1807 geographers had begun to doubt the correctness of Rennell's conclusions, and in that year the Government of Bengal authorised a survey of the river Ganges in the mountains to its source. Captains Raper and Webb were directed to "survey the Ganges from Hardwār to Gangotri, where the "river is supposed either to force its way by a subterraneous passage through "the Himālaya Mountains, or to fall over their brow in the form of a cascade, "to ascertain the dimensions of the fall, and delineate its appearance, and to "observe its true geographical situation in latitude and longitude." (*Asiatic Researches*, Vol. XI, 1810.)

After following the two great branches of the Ganges until they became narrow torrents, the survey officers reported that the sources of the river were on the southern side of the Himālayan chain. We know now, from modern surveys, that both the Alaknanda and Bhāgīrathi rise north of the Himālaya and pass through the great range in narrow gorges. The mistake of Raper and Webb is more instructive than that of Rennell: the latter was merely basing conclusions on hearsay evidence; the former actually penetrated and passed the great Himālaya through stupendous defiles carved by the Ganges,

but so hemmed in were they by mountains, that they entirely failed to understand that they had crossed the snowy range. From the bed of the Ganges on the northern side of the Himālaya, Raper and Webb reported that they had found the sources of the river on the southern side.

Mr. Colebrooke summed up the results of the Raper-Webb expedition as follows:—"If the Bhāgīrathi and Alaknanda rivers had a passage through the "Himālaya, it should follow that the channel of its stream would form the Ghāti "(or pass) by which the snowy range became passable. But since this principle "holds good in practice, and since it is utterly impossible to cross the snowy "range in a direction which the channels of these rivers might be expected to "assume, I consider that at least all former reports are determined fictitious. "No doubt can remain that the different branches of the river above Hardwār "take their rise on the southern side of the Himālaya or chain of snowy moun-"tains."

In 1812 Moorcroft made a similar mistake: he passed through the great Himālayan range by the valley of the Ganges and crossed the Niti pass into Tibet. The Niti pass is situated on a hinder range, and is thirty miles in rear of the Himālaya; nevertheless when Moorcroft, who was an accurate and capable observer, arrived at the pass, he was unaware that he had crossed the Himālaya. (*Asiatic Researches*, Vol. XII, 1818.)

Such mistakes as these bring home to us what a bewildering maze the unmapped Himālayan area really is. "From an extensive experience in Himā-"layan surveying," wrote Colonel Tanner, "I can safely state that even when "carrying on our work with the aid of the best maps, instruments and requisite "knowledge of surveying, we are liable, until we compute out the positions of "our points, to mistake one mountain for another, even though we may have "learnt their appearance by heart from other stations." (*General Report, Survey of India*, 1883-84.)

Colebrooke's conclusion was held to be correct until the fallacy underlying it was explained in 1817 by Captain Herbert of the Survey of India, who showed that both the Alaknanda and Bhāgīrathi rise on the Tibetan side of the great Himālayan range, and that both pierce this range.

Feeders of the Ganges.—The Alaknanda has many feeders that rise north of the line of snow, the Dhauli (Dhauli or Dhauliganga: there are many rivers of this name in the Himālaya, but none as large as this tributary of the Alaknanda) and the Vishnuganga (named also the Saraswati) being the principal. The Dhauli has its source at the Niti pass of the Zāskār range, and the Vishnuganga rises at the Māna pass and Kāmet: they join at Joshīmath (6,000 feet) and here the passage through the great range commences (Chart XXIV).

At Karnaprayāg the course of the Alaknanda is deflected by the Lesser Himālaya range (Nāg Tibba), which also determines the direction of the Pindar

tributary. At its junction with the Pindar the height of the Alaknanda's bed is 2,600 feet.

The Bhāgīrathi issues from the Gangotri glacier behind the Kedārnāth peaks at a point called Gau Mukh, 13,000 feet high. When Captain Hodgson and Lieutenant Herbert visited Gangotri in 1817, they named four prominent snowy peaks, standing near the head of the glacier, St. George, St. Andrew, St. Patrick, and St. David: these names were not accepted by the Surveyor General and have now fallen into disuse: the four peaks of Hodgson and Herbert can be identified with the group, known to modern geographers as Satopanth. The temple of Gangotri, which is visited by large numbers of pilgrims every summer and which contains statuettes of Ganga and Bhagīrath, is situated on the right bank of the Bhāgīrathi 18 miles below Gau Mukh. The temple of Badrīnāth is 10 miles east of the Badrīnāth peaks; it is on the Vishnuganga south of Māna town. The temple of Nanda Devi is 30 miles NNW. of the Nanda Devi peak and separated from it by the Dhauli.

The Jadhganga or Jāhnavi, the westernmost feeder of the Ganges, joins the Bhāgīrathi seven miles below Gangotri temple: their combined waters cut through the great Himālayan range between the peaks of Srikānta and Bandarpūnch, four miles west of the former, eight miles east of the latter, and 13,000 feet below them (Chart XXIV). This gorge of the Bhāgīrathi is "one of the "most remarkable in the Central Himālaya, and for picturesqueness can hardly "be surpassed by any valley in the world. Its sides are often absolutely vertical, "smoothed down by the torrent, which rushes 600 feet or more down below through "a narrow slit in the rocks." (*Geology of the Central Himālayas* by Griesbach; *Memoirs*, *Geological Survey of India*, Vol. XXIII, 1891.)

At Tehri the Bhāgīrathi has cut down 20 feet into the solid rock below the bed of its tributary, the Behling. This is characteristic of the Himālayan rivers, the development of the trunk streams being commonly in advance of that of the lateral feeders. The Alaknanda and Bhāgīrathi unite at Deoprayāg in rear of the Mussoorie range of the lesser Himālaya, and their combined waters pass the latter through a defile.

The snow peaks of Bandarpūnch, Kāmet and Nanda Devi mark the Himālayan watershed of the Ganges, the peaks of Badrīnāth, Kedārnāth, Gangotri and Trisūl rise from the interior of its basin (Chart XXIV). If the snowy range of Garhwāl is viewed from Mussoorie or Hardwār or Sahāranpur, two gaps in the range break the line of the snows; the gap between Nanda Devi and Badrīnāth is the gorge which the Alaknanda has pierced through the range, and the gap between Srikānta and Bandarpūnch is the gorge of the Bhāgīrathi.

The source of the Ganges.—During the earlier half of the nineteenth century there were controversies over the source of the Ganges, and Captain Herbert, who was for many years recognized as the authority on the Himālaya, was of opinion that the Jadhganga was the true source.

It has come however to be recognized that a river, which is being fed from great numbers of glaciers, cannot be referred to any one source, and the question has ceased to be of interest: it is probable that not a twentieth part of the water in the Ganges is derived from any single glacier. If, however, we were called upon now to select the most important source of the Ganges, we should not be able to support Herbert's view. Herbert, not having seen the Alaknanda, assumed that the Bhāgīrathi was the true Ganges, but Sir Richard Strachey has pointed out that the Alaknanda is twice the size of the Bhāgīrathi, and that, if a source is to be named, it must be the Dhauli (*Journal, Royal Geographical Society*, Vol. XXI, 1851).

Some writers define the source of a river as the point of its course, that is most remote from its mouth. Colonel George Strahan has shown that if this definition be applied to the Ganges, its source will not be Himālayan at all but will lie near Mhow in Central India at the head of the Chambal (Chart IX).

The following descriptions are taken from Captain Herbert's report on the Mineralogical Survey of the Himālayan mountains (*Journal, Asiatic Society of Bengal*, Vol. XI, Part II. 1842): "I must not leave the Dhauli, however, "without saying something of those great accumulations of boulder stones, the "very sight of which strikes the traveller with astonishment, and forces him to "admit the action of some great rush of waters. These diluvian beds are here "seen on a scale, which sets at nought any theory that would derive its agent "from the body of water at present occupying that channel."

"The beds of some of the rivers are, for a part of their course, in the solid "rock. In these cases, the depth is often considerable, while the appearance is "such as leaves not a doubt in the spectators' mind but that the present channel "was once filled up with solid rock. This is a conclusion we cannot escape from "however difficult it may be to understand the removal of so many thousand "cubic feet of solid rock by the agency of water."

In 1911 Lieutenant G. Burrard, R.F.A. and Lieutenant Mankelow 39th Garhwāl Rifles followed the course of the Jadhganga in rear of the Great Himālayan range; they reached its principal source at the Jelukhaga pass (Tsang Chok La) (17,490 feet) and crossed the Zāskār range into Tibet. They noted in their diary: "The source of the Jadhganga at the Jelukhaga pass is 3 marches "(15 miles as the crow flies) in rear of the crest-line of the Zāskār range." In the Himālayas it is frequently found that a river which had its original source on the southern slope of a range has cut back through the range and behind the crest-line. The case of the Jadhganga is quoted here, because the parallel case of the Shyok river in the Depsang-Karakorum has been questioned.

The glaciers of the Ganges.—There are numerous glaciers at the sources of the Ganges; many have not as yet been accurately surveyed, but all the most important have been crossed by sportsmen and sketched by surveyors and mountaineers. The Pindari glacier was visited in 1847 by General Richard

Strachey, who measured the rate at which the ice was moving in the middle of the glacier: he found that the rate of motion amounted to 9½ inches a day (*Journal, Asiatic Society of Bengal*, Vol. XVI). In 1906 the Pindari glacier was surveyed and marked by the geologists Cotter and Brown, (*Records, Geological Survey*, Vol. XXXV, 1907). General Bruce, and Dr. Longstaff and Mr. Mumm explored the glacial regions of Nanda Devi and Trisūl in 1907, and Dr. Longstaff was able to correct the map drawing of the Bagini glacier. Mr. and Mrs. Ruttledge of the Indian Civil Service have made valuable explorations of Higher Garhwāl and Kumaun.

The most important sources of the Alaknanda are the glaciers on the north and south slopes of Nanda Devi (both of which are 12 miles long), the Bagini glacier (10 miles), and the Kosa glacier (7 miles), all of which flow into the Dhauli tributary: the Satopanth glacier (7 miles) flows into the Vishnuganga tributary, and the Pindari glacier into the Pindar. The most important sources of the Bhāgīrathi are the Kedārnāth glacier (9 miles), and the Gangotri glacier (16 miles) which flows into the Bhāgīrathi at Gau Mukh, and the Māna glacier (12 miles) which flows into the Jadhganga tributary.

The name Māna has been used somewhat indiscriminately. The town Māna is on the Vishnuganga, which rises at the Māna pass. The Māna peak is on the south buttress of Kāmet, which forms the watershed between the Vishnuganga and the Dhauli. But the Māna glacier flows into the Jadhganga; it was first shown upon a map in 1872 by our surveyors Ryall and Kinney who were experienced and reliable.

The Kāmet expedition of 1931.—In the "Times" of April 4th, 1931 the account of the mountaineering expedition to Kāmet had the striking heading,—"The Sources of the Ganges," and it told the public that the peaks and glaciers above the sources were unexplored. Such a statement did not give a true picture of the geographical position; no picture is true that ignores geographical achievements and that stresses minor omissions. The Survey of India Department made a survey of the Gangetic basin in 1871-74, the sources of the river were mapped, and the peaks standing between the sources were observed and fixed in position and their heights were determined. The detail mapping was not extended over the high unfrequented areas of perpetual ice and snow. The only portions of the Gangetic basin in Garhwāl, which have not been surveyed, are the higher slopes of the snow peaks and the higher areas of glacier ice. These ice-bound heights were omitted from the survey by direction of the Government and with the approval of the Lieutenant Governor, on account of the great expense of such work at high altitudes. The exact position of the peak of Kāmet on the Gangetic watershed had been determined 60 years before the expedition started to climb Kāmet. Its height, 25,447 feet, had been observed from six different stations. The glaciated slopes of Kāmet had not been mapped, but the geographical work of those early surveyors, though not acknowledged in

the "Times", was the basis of the expedition to Kāmet and the foundation upon which the expedition was planned. When an explorer takes the opportunity of instructing the British public through the press, his historical references ought to be verified. The sources of the Ganges in the Kāmet region had been explored not only by sportsmen and surveyors, but by the eminent geologist, Griesbach,—all in the last century.

In the articles contributed to the "Times" by the Kāmet expedition the famous peak of Nanda Devi, well known to both ancient and modern geographers, was called the "peak of the Naked Goddess"; there is no such name in Sanskrit or Indian or Tibetan literature, and this mistake by the writer of the article was even more serious than his historical omissions. The name Nanda Devi means "the Goddess Nanda," (see Chapter 4, Part I).

When, in 1867, Colonel Montgomerie took charge of the survey of Kumaun and Garhwāl, he found that this area and its passes had been explored by enterprising sportsmen up to considerable altitudes.

The difficulties of surveying at high altitudes on the southern Himālayan slopes in Kumaun and Garhwāl were greater than in the Karakorum, as the snowline is lower. Owing to the extensive caps of snow and ice descending to lower levels, it was more difficult to take a theodolite to the triangulation stations above 17,000 and 18,000 feet in Garhwāl than it had been in Baltistān. But when Mr. Ryall the distinguished triangulator reached the higher valley of Garhwāl, *in rear of the Great Himālaya,* he found a diminution of snow and ice, even at 19,000 feet, and his triangulation became less arduous. In the Kāmet region Mr. Ryall found the line of perpetual snow to be on the average 4,000 feet higher than on the southern slopes of Bandarpūnch, Badrīnāth and Nanda Devi, and this rise in the height of the snowline greatly facilitated climbing to high altitudes.

The surveyors and their Garhwāli *khalāsis* were not mountaineers and were not equipped with mountaineering appliances; they were moreover obliged to carry survey instruments. And thus no fair comparison between their work and a mountaineering climb is possible, more especially as the mountaineer's task is completed when he reaches his summit, whereas the surveyor's task only then begins. When Mr. Pocock, the Kumaun surveyor, erected his plane-table in 1872 at a height of 22,040 feet on the Nanda Devi massif, he and his *khalāsis* had to work at an altitude which was higher above the snowline than the summit of peak Kāmet.

Mr. Hugh Ruttledge's attempt to climb Nanda Devi in 1932.—In 1872-74 the Survey of India completed their surveys of Kumaun and Garhwāl. Colonel Thuillier had latterly been in charge of the work, and in the high region surrounding Nanda Devi he had met with mountaineering difficulties. Mr. Ryall had observed with his theodolite at stations above 19,000 feet, and Mr. Pocock had erected his plane-table at 22,000 feet. Such work was necessarily slow, and

its slowness made it costly. For these reasons Thuillier was directed by the Surveyor General to omit from his survey the highest portion of the Nanda Devi area, which may be roughly estimated as a circular area of 18 miles radius or its equivalent. Colonel Thuillier's omission in 1874 of the uninhabited glacial areas from his survey has been criticised in recent years, and it has been said in disparagement that the Survey of India regarded glaciological surveys as "waste of time." Any mountaineer who has studied the survey problems will know that such criticisms are hasty and unjust.

Mr. Ruttledge's description of Nanda Devi, as published in the "Times" on August 22nd, 1932, was both scientific and artistic: it is quoted here in the interests of historic truth, as showing the difficulties which our surveyors were facing sixty years ago.

Mr. Hugh Ruttledge of the Indian Civil Service and his wife are two of the most experienced and courageous of Kumaun mountaineers: they have both travelled into Tibet and have encircled the peak of Kailās. The following extracts are made from Mr. Ruttledge's description published in the "Times," August 22nd, 1932, with the permission of the editor:

"The Nanda Devi massif has a topographical formation of such a character that after nine attempts, the first of which took place in 1883, the very base of the mountain remains untrodden by the foot of man.

"Nanda Devi imposes upon her votaries an admission test as yet beyond their skill and endurance; a 70-mile barrier ring, on which stand 12 measured peaks over 21,000 feet high and which has no depression lower than 17,000 feet, (except in the west, where the Rishiganga River, rising at the foot of Nanda Devi, and draining an area of some 250 square miles of ice and snow, has carved for itself what must be one of the most terrific gorges in the world). Two internal ridges, converging from north and south respectively upon this river, form the curtains of an inner sanctuary, within which the great mountain soars up to 25,660 feet.

"So tremendous is the aspect of the Rishiganga gorge that Hindu mythology ascribed it as the last earthly home of the Seven Rishis. Here, if anywhere, their meditations might be undisturbed.

"In 1907 Dr. Longstaff and General Bruce achieved the only crossing of the barrier wall, which has ever been made: from the north, by the difficult Bagini Pass (20,100 feet). According to the survey map, this should have afforded direct access to Nanda Devi. But the map was incorrect, for the very good reason that the surveyors had never been able to see the ground. Dr. Longstaff made a desperate attempt to force the upper gorge, but was pulled up by impassable cliffs. The problem of the gorges remains unsolved.

"In a mood of hopeful anticipation our party, on May 25, trudged up the narrow glacier which leads to the base of the wall, of which the greater part is invisible from a distance. One step round it, and we were brought up all standing by a sight which almost took our remaining breath away. Six thousand feet of the steepest rock and ice. Nima exclaimed that this looked as bad as Kānchenjunga in 1930.

"Near the top of the wall, for about a mile and a half, runs a terrace of ice some 200 feet thick; in fact, the lower edge of a hanging glacier. Under the pull of gravity large masses constantly break off from this terrace and thunder down to the valley below, polishing in their

fall the successive bands of limestone precipice of which the face is composed. Even supposing the precipice to be climbable, an intelligent mountaineer may be acquitted on a charge of lack of enterprise, if he declines to spend at least three days and two nights under fire from this artillery."

The above extracts will enable future explorers to judge, whether in 1874 the Surveyor General was right in regarding the Nanda Devi heights as impracticable for survey operations, and whether he was justified in his desire to save his officers and surveyors and *khalāsis* from hardship and danger; explorers will also be able to judge whether it is fair now to belittle the work of our predecessors because these glaciated regions were omitted from their maps.

It will be noticed that Mr. Ruttledge explains with sympathy the error in the old maps, and he refers to the 12 peaks on Nanda Devi's barrier all of which are over 21,000 feet high, and all of which had had their heights measured in 1874 by the surveyors.

The Rāmganga (Chart XXV).

The Rāmganga (Chart XXV) is a small river, draining the southern face of the outer Himālayan range of Kumaun. its basin is triangular in shape, because the rivers on either side of it, the Ganges and Kāli have converged in all their branches in order to pierce the outer range, and have thus left a small intermediate triangular area undrained.

The principal affluent of the Rāmganga is the Kosila or lesser Kosi: it rises in the outer Himālayan range and does not join the Rāmganga, until they have escaped from the mountains and entered the plains.

During the gradual rise of the Siwālik range the Ganges and Kāli had sufficient water to wear down the growing range and to maintain direct passages across, but the Rāmganga's small volume was unequal to the task of cutting down the new range, as it rose, and the river was deflected by the latter for ten miles to the north-west, before it found a suitable place for an outlet (*Memoirs, Geological Survey of India*, Vol. XXIV, 1890, Part II, page 15).

The structural trough between the lesser Himālaya and the Siwālik range through which the Rāmganga flows is known as the Patli Dūn: it is of a crescent shape with the concave side facing south: it contains immense terraces of gravel of different heights which have been deposited by the Rāmganga. "It is," writes Mr. Middlemiss, "one of the most beautiful spots that the North-"West Provinces of India can boast. It is undisfigured by villages and *bāzārs*. "A solitary forest bungalow is all that breaks the magnificent monotony of its "billowy forests and grass-grown alluvial flats." (*Memoirs, Geological Survey of India*, Vol. XXIV, page 55).

The Kāli (Chart XXV).

The basin of the Kāli shown in Chart XXV is not identical with the mountain area known as Kumaun for the bed of the Kāli river itself is the boundary between Kumaun and Nepāl, from the snows to the foot hills.

The principal source of the Kāli is the Milam glacier at the head of the Goriganga, (Chart XXV). The town of Milam is on the Gori and is 11,160 feet high; feeders of the Gori descend from the Kingri Bingri La (18,300) and from the Anta Dhura La (17,500). The Kāli has sources also at the Lipu Lekh, Mang Sha Dura La, Darma La and at other passes into Tibet. All these sources of the Kāli and Gori are north of the Great Himālayan range.

The Milam glacier was first explored by Colonel Hodgson in 1817, and subsequently by Lieutenant Weller in 1847. Captain Webb made a survey of Kumaun in 1815-20. The position and height of Nanda Devi were determined in 1845-46.

The Api-Nampa group of peaks stands immediately east of the Kāli: Takachull peak (22,661 feet) rises between the Dharma and Gori affluents, and further west on Chart XXV, we see the axis of the great Himālayan range marked by Nanda Devi (25,645 feet), and Badrīnāth (23,190 feet).

In its upper courses the Kāli river and its two affluents the Dharma and Lissar flow in long parallel beds five miles apart. No one of them rises north of the Zāskār range, but the Kāli itself appears to flow along a furrow in the crest-zone. The long parallelism of the Kāli, Dharma and Lissar rivers in their upper courses shows, perhaps, that minor wrinkles have in this region been superposed on the primary Himālayan folds, * (figure 2, Chart XVI).

The Sarju affluent of the Kāli flowing south-east is on the same alignment as the Pindar tributary of the Ganges; for 100 miles these two rivers continue in one line and the beds of both are possibly occupying an original trough created in rear of the Nāg Tibba range of the lesser Himālaya when the latter was upraised.

Colonel Tanner describes a remarkable waterfall, which he discovered in the basin of the Kāli.

"Taking some guides from Garbiang," he wrote, "I went down the Kāli instead of ascending the moraine, and after a difficult journey found myself at the bottom of the wildest place I have ever been in. On one side rose the cliff of the moraine backed by the mountains on the right bank of the Kāli; opposite towered more cliffs fringed, wherever there was standing room, by forest trees, and down the face of the overhanging scarp in front of me poured the waters from Api in a feathery cascade of great volume and with a fall of between three and five hundred feet.

"The foot of the fall we could not see, as it descended into a deep abyss, where it was lost in the unseen Kāli, which thundered and roared along immediately below our feet, but how far below us we could not say. Sheets of spray filled the cleft of the Kāli and were blown hither and thither across the face of the cliffs, and the sun which was well overhead lit up the great hollow at our feet with a mass of bright prismatic colours.

* "The Lissar river flows during the greater part of its course along the axis of a symmetrical anticlinal formed of carboniferous rocks, leaving it near the end of the Chingchingmauri glacier......this anticlinal is flanked on both sides by a system of other plications more complicated on the north-east." (Griesbach's *Geology of Central Himālaya: Memoirs, Geological Survey of India*, Vol. XXIII, 1891).

"Having visited this fall, which is called the Yangla Dhar, it was a question whether we should return by the way we had come or try and reach my camp by continuing our journey down the valley of the Kāli. We decided on the latter course and though none of my men had previously visited this extraordinary place, they said that there might possibly be a means of skirting the cliffs, but that of course there would be bad places. Bad places there were indeed, and before long when clinging to the rough places in the face of a slope that was nearly a cliff, I fervently wished I had not come, and sometimes had it not been for the friendly grasp of Rinzin's hand, I believe that I should not have emerged safely out of this awful valley. Gradually the dangers of the road became less, and towards evening we reached the most beautiful and charming village of Budi—literally the most delightful place I have seen in the Himālaya.

"At one day's march below Budi the passage of the Nirpania-ki-Danda or waterless ridge commences; it has taken the ceaseless toil of generations to construct the series of stone steps or ladders over which the traveller has to make his way for a day and a half before he reaches an ordinary mountain path. This extraordinary trade-route consists of a kind of winding stair-case, which is carried up and down in the face of cliffs in many places overhung with crags and with seemingly an almost bottomless abyss below. The rough steps are built into the rock wherever it has been possible to find foothold."

The Glaciers of the Kāli basin.—There are numerous glaciers that contribute to the flow of the Kāli river. The most important is that known as the Milam, which is 12 miles long, and which is formed by the junction of nine large tributary glaciers. Its lower portion was surveyed by the geologists Cotter and Brown in 1906, when the position of the snout was marked by pillars and photographed. Cotter and Brown were told by Rai Bahadur Kishen Singh Milamwal that the ice-cave of the Milam glacier had retreated 800 yards within his memory of 57 years.

In 1906 Cotter and Brown also observed the Shankalpa glacier, which is formed by the union of two tributaries, and the Poting glacier. These glaciers were photographed and well surveyed by plane-table; the surveys and the marks, both those erected and those cut on rock near the snouts, constitute a scientific record, that should be of permanent use to our successors in future years. The Bhotia shepherds assured the geologists that the glaciers of Kumaun are all retreating.

The town of Milam situated amid the high glaciers of Kumaun is known now as the birth-place and home of the Pandit Nain Singh, C.I.E., and of the Rai Bahadur Pandit Kishen Singh, two of the foremost and most successful of the early explorers of Tibet. They were first cousins and their family had been held in honour in Milam for many generations. Their fathers Deb Singh and Ber Singh the two sons of Dhamu, were brothers, and it was due to their influence and efforts that the first British explorers of Lake Mānasarowar, Moorcroft and Hearsey, were released by the Tibetans from captivity.

Nain Singh was born at Milam about 1835, and he served in the Survey of India as a Tibetan explorer from 1863 to 1876. He was the first explorer to travel across Central Tibet from Leh to Lhāsa.

Kishen Singh Milamwal, also known as Krishna and famous under his disguise A-K, was ten years younger than Nain Singh, he served in the Survey of India from 1869 to 1885. By his journeys across eastern Tibet in 1878-82 from south to north and back, he proved conclusively that the theory of the Irrawaddy river rising in the Tibet plateau had been based on fallacy. In their record of service Nain Singh was described as a Bhotia, and Kishen Singh as belonging to the caste of Rawat Rājput.

The Lesser Himālayan Ranges of Kumaun.

To trigonometrical and topographical surveyors the question of the Lesser Himālayan ranges has always been one of scientific interest. A distinguished geologist criticised geographers many years ago for laying too much stress upon ranges, and there may have been some justice in his criticism; we may have gone beyond the limits of knowledge and been tempted into conjecture. But that the Lesser Himālayas have been partly built up as linear ranges, and are still existing to a certain degree as linear ranges can hardly be doubted.

The general public are led by their own observations to believe that the Lesser and Outer Himālayas are made up of ranges. The landscape artists that sketch the Himālayas from Simla, Mussoorie and Naini Tāl are generally in agreement as to the difficulties which confront them owing to the parallelism of successive ranges: they seek in vain for a landscape, where some lines may lead the eye into their picture and where the hills cease to arrange themselves in lines crossing the view from right to left.

Triangulators who are observing peaks of the Lesser Himālayas, find it helpful to their geographical understanding, if they can group and classify the peaks by ranges.

In Part II of this book, Chapter 10, we considered the question of ranges from the evidence furnished by the observations of peaks. In Part III the same question may be considered from the evidence furnished by the observations of rivers, (as has already been indicated in the concluding paragraphs of Chapter 19).

Peaks mark the lines of mountain crests, just as lighthouses mark the lines of rocky coasts. Rivers have their sources in the ranges, and owe their existence to the ranges, but from the moment when they are born they begin to destroy the ranges that gave them birth. There is an unceasing struggle between ranges and rivers; the uprising of new ranges blocks and deflects the courses of the older rivers, and the erosion caused by the rivers destroys the rising ranges.

If a river emanating from the high snowy range has been blocked by the rise across its course of an outer and smaller range, it may be compelled to flow alongside the latter, and frequently it may be unable to pierce the latter, until it has been reinforced by other streams draining other portions of the snowy area.

When two Himālayan rivers are seen flowing towards one another along the same linear trough,—and when these two rivers are seen to unite and pierce the mountain alignment that has been blocking their passage to the plains, they furnish evidence of the existence of a Lesser Himālayan range, and if this evidence is confirmed by the observations of peaks, the existence of the Lesser range is established. Although a crest-line may be broken, and although it may appear in places to be curving or overlapping, a long mountain alignment is accepted by geographers as a "range."

From the earliest centuries the Aryan people of India have regarded the Great Himālayan snows from Nanga Parbat to Kānchenjunga as a mountain range, and modern geographers have accepted this view. It has at times been argued that the Himālayas are not a range because in some places rivers have broken through it and because in other places, notably at the Sutlej, the range is not continuous: but these objections are questions of local detail, and if we take a wide view, it will be found geographically correct to say that the Great Himālaya is a mountain range 1,500 miles long.

At the extreme foot of the Himālayas from Kashmīr to Sikkim there is a small outer range known as the Siwālik range which runs parallel to the Great Range. This low range like the higher one can be scientifically regarded as a continuous range, although there are breaks in it too, and although in one place its alignment overlaps (see Part II, Chart XIX, figure 2).

The continuity of the Siwālik range and its close relationship to the Great Himālayan line of snows were realised by the ancient Aryans with whom the name Siwālik originated. They regarded this low range as the edge of the roof of Siva's dwelling in the higher Himālaya.

In his "*Jummoo and Kashmir,*" the geologist Frederick Drew gave to geography a book of lasting value. Referring to the Siwālik range, he pointed out that this line of hills continues east and west always with the same features and character. He wrote, "This chain of hills of enormous length and wonder-"ful uniformity edges the Himālaya along their whole course. The width of "the Siwāliks varies from 14 to 36 miles. Their elevation varies from 1,000 to "5,000 feet."

It is therefore established that the Himālaya Mountains, 1,500 miles long and 120 miles wide, have, firstly, a continuous snowy range marking the alignment of their supreme altitude, and secondly, another equally continuous but smaller range marking their lowest alignment where they descend into the plains.

Between these two chains, the highest and the lowest, the Himālaya *Pahār*, as they are called by the hill-people, form a continuous zone of mountains 100 miles wide, and surveyors have been endeavouring to discover to what extent this intricate belt of mountains bordered by two linear ranges can be subdivided into other linear ranges.

The Nāg Tibba Range.

In Chapter 10 of Part II references were made to the two lesser Himālayan ranges which are traceable through the mountains of Garhwāl and Kumaun, namely, the Nāg Tibba range and the Mussoorie range. On the north-western edge of the basin of the Jumna, the Nāg Tibba range is marked by Jakko (Simla); it runs through the Chaur peak (11,966 feet) and Chakrāta to Nāg Tibba (9,913 feet). It crosses the basin of the Ganges from Nāg Tibba to the nameless peak (10,068) standing south of the Pindar, and it enters the basin of the Kāli north-west of Baijnāth (lat. 30°, long. 79½°). It is pierced by the Bhāgīrathi south of Tehri, just below that river's junction with the Behling, and it crosses the Alaknanda just below the latter's junction (Rudra-prayāg) with the Pindar. It then traverses Kumaun along the south side of the river Sarju, and it is pierced by the Kāli just below the latter's junction with the Sarju. It then enters Nepāl, and its further alignment will be considered in Chapter 21.

The Mussoorie Range.

The Mussoorie range runs from Kasauli and Dagshai along the south side of the Giri: it is pierced by the Jumna just below the latter's junction with the Tons. It passes through Banog, Mussoorie and Landour, and crosses the Ganges just below the junction of the Bhāgīrathi and Alaknanda. It continues through Lansdowne and Naini Tāl into Nepāl (Chapter 21), and possibly even into Sikkim, (Chapter 22).

From the Punjab to Nepāl the alignment of the Siwālik range is almost straight, but it has a slight curvature, convex to the south, in conformity with the Great Himālaya range. The Mussoorie range conforms to the Siwālik curvature, but opposite to Dehra Dūn it separates itself from the Siwālik and forms a bay concave to the south: the space between this bay and the Siwālik range is the Dehra Dūn. The Nāg Tibba range runs almost on a straight alignment from the Punjab to Nepāl, but it curves inwards in conformity with the Mussoorie range, and like the Mussoorie range it has a local bay concave to the south.

CHAPTER 21.

THE RIVERS OF THE NEPĀL HIMĀLAYA.

The Himālaya of Nepāl extend for 500 miles from longitude 81° to 88°. Throughout their length the Great Himālayan range, pierced in places by river gorges, exhibits a line of snow mountains, from the peak of Api on the Kumaon border to the peak of Kānchenjunga on the Sikkim border. Just as Api marks the western border of Nepāl, and Kānchenjunga marks the eastern border, so does Mount Everest mark the northern border separating Nepāl and Tibet. The Nepālese peaks of Gauri Sankar and Gosainthān have shrines of pilgrimage at their base; the peak of Makālu is well known in modern geography from the writings of Schlagintweit, Tanner, Bruce and Howard Bury. The snow peak of Dhaulāgiri, at one time believed to be the highest mountain in the world, has been an object of interest to the dwellers in the hot plains of Gorakhpur for many centuries.

The discovery of Mount Everest.

Mount Everest was discovered by the Survey of India; and not by any individual observer: its discovery was due to the organised co-operation of observers and computers. For this reason no account of the discovery was given in Part I of this book; but after Part I had been sent to press, it became evident that an incorrect story was obtaining circulation, and it has therefore been considered advisable to state the simple facts. The story that has been published is to the effect that one day in 1852 the Chief Computer of the Survey rushed into the Surveyor General's room exclaiming, "I have discovered the highest mountain in the world." A consideration of the circumstances of 1852 will show that no such words could have been uttered.

The discovery of Mount Everest could not have been made, had not accurate chains of triangulation been observed along the plains at the foot of the Nepāl Himālaya in 1845-50. The triangulators in the field had been directed to observe the Himālayan peaks that were visible from their stations of triangulation, and they observed numerous rays to numerous peaks; certain peaks such as Nanda Devi, Dhaulāgiri and Kānchenjunga were so prominent that the triangulators were able to recognise them from all observing stations. But other peaks, such as Mount Everest and Gauri Sankar, were more hidden by intervening mountains and though they were observed from several stations, the observers did not re-identify them, as they moved along the plains from station to station. Triangulators used to plot their rays in rough diagrams upon a chart, so that when several rays all met at a point, they could generally tell in the field whether they had fixed an unknown peak. If a single triangulator

had been observing from all the stations, it is possible that he might have learnt from his diagrams in the field, that he had fixed a very high unknown peak in Eastern Nepāl. But owing partly to the disablement of the triangulators by malaria, and partly to the joining up of different chains of triangulation, the observations in 1849 and 1850 that fixed Mount Everest were made by different observers, observing from different stations. This distribution of the work did not detract from its accuracy or value, but it prevented the individual observers from drawing conclusions in the field. The height of Mount Everest was subsequently re-observed in 1880, in 1881, and in 1902, but these observations do not affect the question of the original discovery.

When the triangulation was completed in 1850, the angle-books of the observers were handed over to the Computing Office, where they were analysed and their results abstracted. The computations of the height of Mount Everest were not the work of a single computer: all the calculations were made in duplicate, the horizontal angles were computed first and the vertical angles at a later date, and not necessarily by the same computers. The work of different computers was compared at intervals, and the Chief Computer was consulted when any unusual result was obtained.

The Computing Office was in touch with the Surveyor General throughout the calculations. The problem of atmospheric refraction was in those days a source of perplexity; a ray observed to a high peak, where the cold was intense, from a low station in the plains, where the heat was great, passed through an ever-changing atmosphere, and its path was so curved and distorted that an observed height was liable to an error of hundreds of feet. Of the six stations from which Mount Everest was fixed, the highest was only 255 feet above the sea, and of these six stations the nearest to Everest was 108 miles from it. Sir Andrew Waugh, the Surveyor General, joined the triangulators in the field south of Sikkim; both he and Rādhānāth Sikhdār, the Chief Computer, had been studying the question of atmospheric refraction for many years; and were well aware that all the vertical observations contained an element of uncertainty.

In 1852 the Chief Computer, who had been unofficially in touch with the Surveyor General, sent his official intimation to the latter that a new peak had been computed from the angle-books to be *higher than any peak hitherto observed.* In this intimation he could not have said, as he is reported to have done in the story circulated, that he had discovered the highest mountain in the world, for the Himālayas had only been partly observed, and Tibet and Baltistān were quite unknown.

The following quotation from Keith Johnston's geographical gazetteer in 1864 will show how cautious the Survey of India were, before they made public a definite announcement of the discovery. Mount Everest was observed in 1849, and yet in 1864 Keith Johnston wrote: "Kānchenjunga is at present "regarded as the most elevated summit on the globe: another mountain mass

"hitherto not accurately measured is believed to exceed 28,000 feet. It lies "about 80 miles west of Kānchenjunga. It seems probable that in Tibet peaks "may yet be found which are still loftier." The words "hitherto not accurately measured" refer probably to the great difficulties the computers had in dealing with atmospheric refraction.

The question still remains, "By whom was Mount Everest discovered"? It is certain that the Chief Computer never regarded himself as the discoverer. The Chief Computer was a mathematician, and he knew that all the necessary observations and measurements of the new peak had been entered in the field by the observers in their angle-books. The calculations of results from the observations were not regarded as original discoveries.

We cannot therefore say that Mount Everest was discovered by the Computing Office, for the computers were depending upon the observations taken in the field. And we cannot say that any single triangulator was the discoverer; the triangulators were the first scientific geographers to take observations to Mount Everest, but as far as we know now, no one of them was aware at the time of his observations that he was observing a peak higher than Kānchenjunga.

As K^2, the highest peak of Karakorum, is spoken of as having been discovered by Colonel Montgomerie, it may be well to recall the circumstances in order to show how different the incident was from that of Mount Everest. When Colonel Montgomerie first observed the highest peak of the Karakorum, he believed (according to tradition) that it was the highest. The tradition that he called it "the giant" at the time of his theodolite observation was not only extant in the Survey, but is still extant amongst Montgomerie's children.* Whether he conjectured that it was the highest from its prominence, or from its snow, or from solar reflections before sunrise and after sunset, it is not known. Montgomerie himself was most modest, and never referred to a discovery. He merely wrote, "It was across the plains of Haramukh that I took the first observation to peak K^2 at a distance of 137 miles." Whilst it was always considered right by his contemporaries to single out Montgomerie as the discoverer of peak K^2 no one of the observers of Mount Everest was at the time of their observations named as its discoverer. After the lapse of 80 years nothing more definite can now be said than that Mount Everest was discovered by the Survey of India.

The symbols employed to designate the satellite peaks of Mount Everest.

The system adopted by the Survey of India of naming high peaks is the outcome of 100 years' experience. The co-operation of mountaineering expeditions in this system will be always appreciated. Within the mountain zone which follows the Tibeto-Himālayan border many thousands of peaks are situated and two networks for distinguishing the peaks have been thrown over them

* See letter in the Field newspaper, December, 1923.

independently of one another; firstly came the network of poetic nomenclature which the various hill-peoples have attached to their peaks, and secondly there followed the network of scientific points which have all been named by means of scientific symbols. The principle observed by the Survey has been to confine its activities to the scientific net, and faithfully to record the popular nomenclature without adding to, or interfering with it.

On one occasion only has the Survey departed from principle, and trespassed upon the people's ground; the case of Mount Everest has been the only exception to its rule. In this case the requirements of world-wide geography could not be overlooked; the highest mountain in the world could not be left permanently nameless. The only disadvantage of the name Mount Everest has been the creation of a precedent; but the case was unique, it can never occur again, and the Survey has for 70 years refused to regard it as a precedent.

The method which the Survey has adopted for distinguishing the many hundreds of nameless Tibetan peaks from one another has been to classify all the peaks of one group under a letter of the alphabet and then to add a separate number to each peak. This same system is followed in many other branches of science.

The Karakorum peaks were named K^1, and K^2, and K^{11}, etc. In many regions however a group name like Karakorum has not been available, and after the Lhāsa expedition of 1904 Colonel Ryder designated his numerous peaks by the group letter R, and Colonel Wood designated his many observed peaks by the letter W. Thus we have many such symbols as W^{166} and W^{167} for peaks on the Southern Tibet Watershed and W^{215} and W^{216} for peaks in Trans-Himālaya: and we have many such symbols as R^{226} and R^{227} north of Lhāsa. When no group letter is obtainable from a region, it is convenient to have the observer's initial as the group letter. Observations, such as Ryder and Wood were able to make in Tibet to so many peaks, are of rare occurrence, and the initials of the observers form historic landmarks in the records. The Trigonometrical Survey keeps a control over the group letters so as to avoid duplication. Objections have been raised, but not by the Survey, to the designations B. W. 3, B. W. 5, etc., given to peaks observed by the Bullock-Workman expeditions, but there is no scientific objection to these designations: they are distinct and they show their history. It would be objectionable if an observer named a peak after himself, but there is no objection to the use of his initials in a scientific formula.

In 1921 the map prepared by the Mount Everest expedition made a new departure. The map-makers in London took the English names which had been useful to mountaineers in the field, and with the aid of a Tibetan linguist they converted these names into Tibetan names. The Asiatic Society of Bengal has rightly objected to these spurious Tibetan names. If such a system be continued it will lead to chaos. It will mean that every explorer has a right

to invent Tibetan names. In the future when the origin of these inventions has been forgotten, map-students may be misled into drawing philological conclusions from them, and travellers when planning an expedition may be led to imagine that a district covered with Tibetan names must have a resident population.

Moreover Tibetan names when invented are never in harmony with local thought. The peak in Nepāl, which is 2 miles south of Mount Everest, was given in London the Tibetan name "Lhotse" meaning "south peak"; this peak stands just inside the northern boundary of Nepāl. In the map of Nepāl the peak named "south peak" will be shown in the extreme north of the state. Also on the other side of this boundary it will be necessary to explain to Tibetans that the peak near the southernmost limit of their country has been given the Tibetan name "Changtse," meaning "north peak." There is both a scientific and an artistic side to mountain nomenclature; scientists are not qualified to add to the nomenclature of the people. If we regard the Himālayan-Tibetan nomenclature as a whole, it presents a wonderful picture of historic art, and a geographer has no more right to add to it his own ideas, than he has to add colours to Raphael's Madonna in the National Gallery.

On the flanks of every great peak there are numerous excrescences which may become triangulation points; but these satellite peaks, partly hidden by their giant companion, have not the importance of an independent isolated summit. In the case of Tirich Mīr its satellites have been named Tirich Mīr II, Tirich Mīr III, etc., and the same plan has been adopted in the case of Teram Kangri. But the name Mount Everest is not a local name; it is a world-name; and it was not considered advisable to extend this unique name to all the satellite peaks on its slopes. The satellites of Mount Everest have therefore been given the group letter E, and have been designated E^1, E^2, E^3 in the tables II to V of Part I. It was considered better to give the designation E^1 to the highest satellite and not to Mount Everest itself. Mount Everest is not a *primus inter pares*; it is of interest to the world, whereas its satellites have only a local interest.

In the past the Survey was in sympathetic touch with the Stracheys, with Drew, with Neve, and many other mountain-explorers, and in this matter of name-inventions it feels it can count upon the co-operation of the mountaineers of to-day.

The First Survey of Nepāl, 1924-27.

The Himālayan state of Nepāl embraces the basins of the three largest rivers of the Himālaya, the Karnāli, the Gandak, and the Kosi; we are excluding the Brahmaputra and the Indus from our comparison, as these two latter rivers are Trans-Himālayan. The two lesser rivers of Nepāl are the Rāpti and the Bāghmati.

The following extracts are made from the report by Colonel-Commandant Sir Edward Tandy on the first Survey of Nepāl. Geographers interested in the subject should study the whole report (*Survey of India, General Report, 1926-27*) :—

"In 1924 His Highness Mahārāja Sir Chandra Shamsher Jung Bahadur, Prime Minister and Marshal Supreme Commander-in-Chief of Nepāl, asked for the co-operation of Indian Surveyors of the Survey of India in preparing complete modern maps of the whole of Nepāl. This enlightened act has resulted in one of the greatest single contributions to Himālayan Geography which has ever been made, by giving us for the first time accurate knowledge of the drainage and structure of 55,000 square miles of country, extending over some of the greatest mountains of the world, and including the highest known peak, Mount Everest."

"A complete contoured map on the scale of 8 miles to 1 inch was required, but the field work was carried out on the more convenient scale of 4 miles to 1 inch."

"Two Nepālese officers, Lt.-Colonel Ganesh Bahadur Chattri and Captain Ganj Bahadur Karki, were placed in control of the Survey, and their untiring efforts in organising transport and supplies were the main essentials in the successful accomplishment of the work."

"*Season 1924-25.*—Work commenced at Kātmāndu in November 1924, when Messrs. Jugal Behari Lal and Lalbir Singh of the Upper Subordinate Service of the Survey of India, with one surveyor and one computer, also of the Survey of India, reported themselves to the Nepālese officers in charge."

"*Season 1925-26.*—The strength of the detachment was raised to fourteen by the addition of ten more surveyors. Mr. Jugal Behari Lal remained in charge, and in addition to supervising the surveyors he extended the triangulation with the assistance of Mr. Lalbir Singh."

"*Season 1926-27.*—The detachment remained at the same strength, with personnel unchanged, and completed the topography. Field work was finally closed in March 1927. The total area surveyed, 55,000 square miles, covers the whole of Nepāl up to the borders of previous Indian Surveys."

"The country surveyed presents great diversities of climate and relief. On the south it is bordered by a low-lying tract of Tarai, covered with forest and very malarious. The centre of the country consists of steep hills 5,000 to 10,000 feet high, largely forest covered and intersected by deep valleys. It is bordered on the north by the main axis of the Himālaya, a region of high cliffs and perpetual snow, where survey is made additionally difficult by mist and cloud."

"*Accuracy of the Survey.*—Considering that the triangulation had to be carried out concurrently with the topography in the first two seasons, and the many difficulties presented by the country, the resulting surveys show evidence of a satisfactory degree of accuracy. It is believed that the maximum errors of topography can hardly exceed half a mile anywhere, and that the average error of plane-table fixings throughout the work should be well within one quarter of a mile, or about one thirtieth of an inch on the 8-mile scale."

"The successful completion of this survey in the short time of three years, in spite of the difficulties of climate and topography, is a notable achievement and reflects great credit on all the officers and surveyors concerned."

"*Nomenclature of peaks.*—The Nepālese only give specific names to a few snow-covered peaks of remarkable aspect, but each group of snowy peaks is called a Himāl, or "Abode of Snow," and receives a name. Thus Mount Everest dominates the Māhā Langur Himāl; Kānchenjunga the Singālila Himāl; Dhaulāgiri, a Himāl of the same name; Gauri Sankar, the Rolwāling Himāl;

and Api, the Viyās Rishi Himāl. Mount Everest itself, whose steep southern face carries little snow, is inconspicuous from the south and has received no Nepālese name. It has recently been suggested that the Tibetans give Mount Everest the name of Chomolomo, but Lt.-Colonel Ganesh Bahādur of Nepāl, considers that this name is used for the whole northern side of the Māhā Langur Himāl, and that it is not the name of the peak."

"In view of Captain Wood's work in 1903 and the full summary of the situation published in 1904 in "Nature," Volume LXXI, pages 42-46, it is surprising that some European geographers still persist in giving the name Gauri Sankar to Mount Everest. By enquiry in the immediate neighbourhood, the name of Gauri Sankar was definitely found to apply to the twin peaks (23,440 feet) situated over 30 miles west of Mount Everest, as identified by Captain H. Wood in 1903. The local inhabitants frequently use the alternative name of Gaura Parbatta. Either name implies the idea of Shiva and his wife, and is suitable to these twin peaks, but would be quite inapplicable to the isolated pyramid forming the summit of Mount Everest."

Sir Edward Tandy's report shows the mistake of applying the name Gauri Sankar to Mount Everest. The advocacy of the name Devadhunga is not a mere mistake, it is due to a difference in outlook. Devadhunga is a name attached in ancient literature to a famous mountain, the position of which was not defined. Now that Mount Everest is famous, linguists contend, "this must be Devadhunga." But as the name is not known to the people of Nepāl nor to the residents of Northern Bengal, it is not suitable for modern geography.

The Karnāli (Chart XXVI).

The Karnāli, known in the outer hills as the Kauriala, is the Himālayan river that subsequently crosses the plains of India at Fyzābād under the name of Gogra. The north-western sources of the Karnāli were explored during the last century by the brothers Richard and Henry Strachey, by Colonel Tanner and other surveyors, and its upper course south of lake Mānasarowar and peak Gurla Mandhāta was traced from Tibet to the Nepālese shrine of Khojarnāth. The basins of the Karnāli and Sutlej are in contact in Tibet. Mr. Sherring's book on 'Western Tibet,' 1906, gave a good account of this region.

The following typical extracts are taken from the diary of a native explorer, who followed a branch of the Karnāli in 1873 from Tibrikoṭ (7,226 feet) as far as the Diji pass (16,880 feet), which is on the water-parting of the Gandak just north of Dhaulāgiri:

"From Tibrikot I followed the course of the river Bheri and reached "Charka on the 4th September, having passed some Lāma-serais on the road. "One of them called Barphang Gonpa contains 40 or 50 Lāmas. Near another "named Kanigang Gonpa, the river has high perpendicular rocky banks, and the "people have made a tunnel 54 paces in length through the rock. There was "originally a crevice, and the rock on either side of it was cut away sufficiently "to allow of a man with a load to pass through with a squeezing, the height of "the tunnel not being sufficient in all parts to admit of his going through standing."

"Charka is the last village on the river Bheri: on the opposite side of the "river is a Gonpa (Lāma-serai) to which the first-born male of every family in the "village, as is the practice amongst the Buddhists generally, is dedicated as a Lāma. "I left Charka on the 5th and ascended the Diji La, about 16,880 feet above sea-"level (called by Gurkhas Balali-Patan) by a gentle incline."

"On either side of the pass there are snow-covered ridges. The pass is "broad, and there is a cairn on it at the watershed."

The recent survey of Nepāl has furnished the first reliable map of the Karnāli; it has shown that the old explorers failed to discover the remarkable "hair-pin" bend in the main course of the Karnāli, (lat. 28°40′, long. 81°30′). This bend was completely missed. The new survey has also shown that the sources of the Bheri tributary of the Karnāli are mostly derived from glaciers of the Great Himālaya range, and that only one of its important feeders which rises near the Diji pass has a Trans-Himālayan source. It has also now been discovered that the Karnāli itself drains the whole Trans-Himālayan trough, 200 miles long, from Gurla Mandhāta almost up to the Diji pass. The north-western arm of the Trans-Himālayan Karnāli, a hundred miles in length, has for many years been known to have its sources near those of the Sutlej west of Gurla Mandhāta; but it has never been suspected that the Karnāli had a north-eastern arm also Trans-Himālayan, longer even than the north-western. The new survey has introduced considerable alterations in the representation of the Babai tributary and has largely reduced its drainage area.

Whilst the Survey of India has no other feelings but sympathy and admiration for European explorers, whose explorations in the Karakorum have received so much attention at meetings in Europe and in the European press, it is necessary to explain here, that the geographical discoveries by the recent Nepāl Survey have been as important and far-reaching as any of the glacier-explorations of recent years in the Karakorum. The former do not receive the same public notice as the latter, because they deal with an area of which little is known.

It had been thought that the Himālayan peak of Api (23,399 feet) was situated in the basin of the Karnāli, but the recent survey has shown that it is standing on the watershed between the Kāli and the Karnāli.

The great south-eastern tributary of the Karnāli is the Bheri or Bheri Ganga: the junction of the Karnāli with the Bheri is at Kuina Ghāt, which is outside the Mahābhārat range (but inside the Siwālik range). The main affluents of the greater rivers generally unite behind the Mahābhārat range before forcing a passage, and the Karnāli itself joins its tributary the Seti before it pierces the Mahābhārat range. Of the lesser Himālayan ranges the Mahābhārat has had a stronger influence than the Nāg Tibba upon the Karnāli drainage, although the Nāg Tibba is the higher range. The presumption is that the Nāg Tibba must be considerably older than the Mahābhārat, and has suffered more from erosion by the rivers.

It is not possible to give details concerning any of the glaciers of the Karnāli: from peak Api to Dhaulāgiri the Karnāli has innumerable glacial sources in the snowy range, but none has been closely observed. The recent survey shows that all the glaciers on the south side of the Himālayan crest are transverse: it is unlikely that any of these exceed 12 miles in length. It is possible that glaciers exist on the north side of the Himālaya north of Tibrikot and Dhaulāgiri.

The Rāpti (Chart XXVI).

The representation of the river Rāpti and of its drainage basin have been considerably altered by the recent survey of Nepāl. In the 1907 edition of this book the authors referred to the uncertainty that was then felt concerning the Rāpti. The recent survey has shown that the Rāpti rises not in the Mahābhārat Lekh (range), as had been believed, but well behind it. It cannot however be said to be rising in the Nāg Tibba range, because the latter only branches off from the Great Himālaya north of the Rāpti: the Rāpti has its sources in the trough in rear of the Mahābhārat. Its triangular mountain basin which has become fitted in between the convergences of the Karnāli and Gandak is shown in Chart XXVI.

The Gandak (Chart XXVII).

The Gandak river is the Sadanira of Sanskrit and the Khondocates of the Greeks. The main stream of the Gandak is known in Nepāl as the Salgrāmi and in the outer hills as the Nārāyani, or Sapt-Gandaki. The name Sapt-Gandaki, denoting the accumulated water of the seven Gandaks, is a poetical generalisation borrowed from the name Sapt-Sindhavas given to the Ganges in the Vedas.

The tributaries of the Gandak have cut gorges through the Great Himālayan range, and now drain the trough between the great range and the Ladākh range of Tibet; they are the Kāli Gandak and the Trisūli Gandak: the former of these drains the glaciers of Dhaulāgiri and has a source as far north as the Kore or Phuto pass of Tibet. Two other tributaries, the Buri Gandak and the Marsyāndi, have cut back behind the great Himālayan crest, but have not reached the trough in rear.

All the glacial tributaries of the Gandak converge and unite to form one great river in order to penetrate and pierce the Mahābhārat Lekh, the range which blocks their descents. In Chart XXVII the long west-to-east course of the Kāli Gandak, south of latitude 28°, illustrates the blocking influence of the Mahābhārat Lekh; the long east-to-west course of the Trisūli Gandak has been due to the same influence. As already mentioned in the case of the Karnāli, the Gandak's branches have been less affected by the Nāg Tibba range crossing their drainage than by the smaller Mahābhārat range.

Numerous glaciers of the Great Himālaya flow into the higher tributaries of the Gandak; those descending on the south side are all tansverse and appear less than 12 miles in length. It is possible that longer glaciers exist on the north side of Annapurna and Jugal Himāl, where the drainage tends to be longitudinal.

In 1849, Mr. Brian Hodgson, the British Resident in Nepāl, wrote of the Gandak as follows:

"In the basin of the Gandak we have, successively trom the west, the "Barigar, the Nārāyani, the Sweti-Gandaki, the Marsyāndi, the Daramdi, the "Gandi and the Trisūl. These are the 'Sapt-Gandaki' or seven Gandaks "of the Nepālese, and they unite on the plainward verge of the mountains at "Tribeni above Saran. They drain the whole hills between Dhaulāgiri and "Gosainthān, the Barigar and one head of the Nārāyani rising from the former "barrier, and the Trisūl with every drop of water supplied by its affluents from "the latter. Nor does a single streamlet of the Trisūl arise east of the peak of "Gosainthān, nor one driblet of the Barigar deduce itself from the westward of "Dhaulāgiri."

Mr. Hodgson's information, which he obtained during his long residence in Nepāl, has been shown by the recent surveys to be accurate. The fact that the names he gave to the rivers do not exactly agree with those learnt by the Survey 80 years later has no significance, as a river's names in the Himālaya are frequently different along different sections of its course.

The Bāghmati (Chart XXVII).

The Bāghmati rises near Kātmāndu and drains a small valley in rear of the Mahābhārat Lekh (range).

Colonel Kirkpatrick visited Kātmāndu in 1793, and subsequently published an account of the Nepāl valley. In 1805 Colonel Crawford, who was afterwards Surveyor General of India, conducted surveys in Nepāl, and measured some of the peaks of the Himālaya, being the first to discover their immense height. The records of Colonel Crawford's observations were lost, but a few of his results were given in Buchanan Hamilton's '*Account of the Kingdom of Nepāl.*' From 1805, when Colonel Crawford took observations, to 1903, when Colonel Henry Wood was permitted by the Nepālese Government to observe the peaks of Gauri Sankar and Mount Everest, no survey officer was allowed to enter Nepāl.

The Kosi (Chart XXVIII).

The river Karnāli drains the Himālayan snows from peak Api on the Kumaun border to peak Dhaulāgiri: the Gandak drains the snows of central Nepāl from Dhaulāgiri to peak Gosainthān, and the Kosi drains the Himālaya from Gosainthān to Kānchenjunga on the Sikkim border.*

* On Chart XXVIII the peak of Gosainthān is shown by its height number only, 26,291 feet.

According to Hindu legend the Kosi is Kausika: the basin of the Kosi is called by the Nepālese the Sapt-Kosika, the country of the seven Kosis: the recent survey of Nepāl gives the name Sapt-Kosi to the river at its point of issue from the mountains into the plains.

As has already been mentioned in the case of the Sapt-Gandaki, the idea of a river, formed by the union of seven branches, originated in the Sapta-Sindhavas of the Vedas (see Chapter 20, Jumna); the mystic number seven has been extended from the Ganges to the Gandak and Kosi. The Indian province of the Persian empire of Darius the Great was described as "the land of the seven rivers" (Hapta-Hendu) in the rock inscription on the tomb of Darius (B. C. 520). The word Hendu is said by etymologists to be a corruption of Sindhu (river) and to be the origin of the name Hindu.

The six great Himālayan branches of the Kosi river in their order from west to east are the Indrawati, the Bhote Kosi, the Tamba Kosi, the Dudh Kosi, the Arun, and the Tamur Kosi. The Indrawati, the Dudh Kosi, and the Tamur Kosi all have their sources in Himālayan glaciers, the Dudh Kosi draining the southern slopes of Mount Everest and the Tamur Kosi draining the western slopes of Kānchenjunga.

The Bhote Kosi and the Tamba Kosi have both cut back through the crest of the Great Himālayan range west of Gauri Sankar.

The four western rivers Indrawati, Tamba, Bhote and Dudh flow down in a transverse direction from the Himālayan crest, but they are blocked by the Mahābhārat range, which has risen and formed a longitudinal trough, along which they have been compelled to flow. The united stream of these four rivers in their longitudinal direction has been given the name of Sun Kosi. The eastern branch of the Kosi, the Tamur, after its descent from Kānchenjunga is diverted into the longitudinal trough of the Mahābhārat Lekh, and meets the Sun Kosi flowing in an opposite direction.

The largest branch of the Kosi is the Arun, which has cut a gorge back through the Great Himālayan range and which now drains the whole Tibetan trough behind the great range from Gosainthān to Kānchenjunga. No tributary of any Himālayan river, with the exception of the Brahmaputra and Indus, drains so long a section of the Himālayan hinterland as the Arun. The Tibetan name for the Arun is the Phung Chu.

The Nāg Tibba range, which crosses the outer Himālaya of Kumaun and of Western and Central Nepāl, becomes joined to the Great Himālaya at Dhaulāgiri, and does not therefore, traverse the basin of the Kosi. But the Mahābhārat range has had a controlling influence upon the drainage of the Kosi; it has obliged both the western and eastern branches of the river to change their direction, and to unite at Dangkera with the Arun in order to force a passage through the Lesser range.

The Mount Everest expeditions.—Valuable topographical knowledge of the upper basin of the Arun was gained between 1921 and 1924 by the three Mount Everest expeditions which were organised by the Royal Geographical Society and the Alpine Club.* The Surveyor General, Colonel Ryder, obtained permission for two officers of the Survey of India, Major H. T. Morshead and Captain E. O. Wheeler, to be attached to the first Mount Everest expedition, and Colonel Howard Bury, the leader of the expedition, gave them all the assistance in his power. On the second expedition its leader General Bruce invited Morshead to join him as a mountaineer. Morshead's and Wheeler's surveys enabled a map to be produced on the comparatively large scale of 1 inch to 1 mile, and this map of the northern glaciers of Mount Everest, Gauri Sankar and Makālu is an interesting record, as it furnishes the only detailed information we possess of Himālayan glaciers on the Nepāl-Tibet border,—a border that runs for 500 miles through unexplored glacial regions. Detailed knowledge of the glaciers of Kānchenjunga has been gained from the maps made in 1879-84 by three officers of the Survey of India, Lieutenant Harman, Mr. Robert and Colonel Tanner, and from surveys made more recently by enterprising mountaineers in their successive attempts to climb the peak. But Kānchenjunga is too isolated a pyramid to be regarded as a typical peak of the Nepāl—Tibet border.

Morshead and Wheeler made a detailed survey of the Rongbuk glacier and of its two branches which descend from Mount Everest on the northern side the Himālaya; the total length of this glacier, allowing for bends, does not exceed 12 miles. The recent Nepāl survey has furnished a map (scale 1 inch to 8 miles) of the southern side of the Himālaya range opposite to the Rongbuk glacier; it does not appear that there is any glacier 12 miles in length on the south side of Mount Everest.

Glaciers of the Kosi.—The longest glaciers known in Nepāl are the two glaciers, Kānchenjunga and Yalung that drain the western slopes of Kānchenjunga, and constitute the principal sources of the Tamur Kosi. The Kānchenjunga glacier has been estimated to be about 16 miles long and the Yalung about 13 miles. These glaciers are more longitudinal than transverse, for Kānchenjunga unlike Mount Everest is rising from an abnormal bend in the general alignment of the snowy range. Owing to this bend Kānchenjunga is not situated upon a range trending from east to west as Mount Everest is, but upon a local trend from north to south. The Mount Everest range runs at right angles to the Nepāl drainage, but the Kānchenjunga range runs parallel to the drainage of the Tamur Kosi. The Kānchenjunga bend may have been caused by the Tamur Kosi cutting back through the great range by head erosion;

* *Mount Everest: the Reconnaissance, 1921.*
The Assault on Mount Everest, 1922.
The Fight for Everest, 1924.

if this has been the case, the Tamur Kosi has cut back upon a broad front instead of piercing the range by a narrow gorge, like that of the Arun Kosi, the Bhāgīrathi, or Alaknanda.

Nepālese nomenclature.

An interesting and useful contribution to the geographical nomenclature of the Himālaya Mountains has been made by the recent Nepāl Survey, which has introduced two Nepālese names corresponding to the English words 'range'; or 'ridge'; the two names, both of which are of Aryan origin, are *Himāl* and *Lekh*. The importance of these additions will be realised if it be remembered that no word exactly denoting a line of elevation has hitherto been forthcoming from the Himālayan people. The word in general use in Kumaun, Garhwāl, Kāngra, and Kashmīr is *Pahār*, but *Pahār* means a mountain or mountains of any form. A peak is called *Pahār*, such as Nanda Devi *pahār*, a mountainous district is called *pahār* such as Kulu *Pahār*, and the word *Pahār* is nowhere limited to a linear "arrangement," for which the English word "range" is the abbreviated form.

In Nepāl almost every snowy ridge and every section of a snowy range is called *Himāl*, and almost every mountain range or ridge without snow is called *Lekh*. In Sir Edward Tandy's report quoted at the beginning of this chapter some of the most important *Himāls* are mentioned by name. Many of the *Himāls* have Aryan names prefixed to them, and many have Mongolian prefixes.

The Nepālese word Lekh, denoting a comparatively low range of hills, is in use all over Nepāl. It has been known in Himālayan geography for 100 years from the Lipu Lekh pass which is at the source of the Kāli river and which leads from Kumaun into Tibet, and from the Lankpya Lekh west of Lipu Lekh.

The Lipu Lekh pass has at times been called the Lipu Lekh La, and has been assumed to be a combination of three Tibetan words, but this assumption has been wrong, for though Lipu and La are Tibetan, Lekh is Nepālese and Aryan.

Sir Charles Bell writes:

"*Lekh* is a Nepalese (Khaskura), not a Tibetan word. I had to speak Khaskura for many years, as it is the *lingua franca* of the Nepalese, and in Darjeeling district and Sikkim the Nepalese constitute three-fourths of the population."

"*Lekh* and *aul* (or *Awal*) are words in very common use in conversation. *Aul* is the low land below 3,000 feet, or thereabouts; *lekh* are the uplands, five or six or ten thousand feet and even higher. If you want to describe a place 12,000 or 14,000 feet up, you would say '*Saro lekh chhu*,' 'it is very much upland'. *Lekh* you may say is the land above the malaria level. 'I can live in *lekh*; I cannot live in *aul*,' is often said."

In Part I of this book an appendix on the Linguistic Survey of India was included, and in this appendix the following reference was made to the Indo-Aryan language, which Sir George Grierson calls the Eastern Pahāri :

"Eastern Pahāri is sometimes called Parbatiya, sometimes Gorkhāli, some-"times Khāskhura ; it is not spoken outside Nepāl except by soldiers of the "Gurkha regiments."

The Lesser Himālayan Ranges of Nepāl.

The references in Chapter 20 to the Lesser Himālaya ranges of Garhwāl and Kumaun are applicable to the Lesser ranges of Nepāl.

The Nāg Tibba range.—The Nāg Tibba range leaves Kumaun and enters Nepāl below the junction of the Kāli and the Sarju rivers. From the Seti to the Karnāli its alignment is difficult to trace, but east of the Karnāli its crest-line can be followed through the Mahabu pass and peak Thari Patan and Taridwari Dara (17,695 feet) to its conjunction with the Great Himālayan range at Dhaulāgiri. It has been intersected by many rivers.

The Mahābhārat range.—The Mahābhārat range enters Nepāl from the west at the Kāli river south of its junction with the Ladhiya : it can be traced through Ghanteshwar (8,383 feet) and Kedār, and it crosses the Karnāli river at Belgaon. Although the Mahābhārat range and the Mussoorie range (of Garhwāl) have had the same influence upon river-drainage, surveyors have not felt justified in stating that the Mahābhārat range is a continuation of the Mussoorie range of Garhwāl (see Chapter 10, Part II). The new map of Nepāl, which was issued after Part II had been written, does not remove all doubts as to the unity and continuity of the Mussoorie-Mahābhārat alignment. But this map does justify the conclusion that the long continuous Mahābhārat range of Nepāl has in Nepāl the same relationship in position and height, both to the great snowy range and to the low Siwālik range, as the Mussoorie range has to the snows and Siwāliks of Garhwāl-Kumaun, (see Chapters 20 and 22).

CHAPTER 22.

THE RIVERS OF THE ASSAM HIMĀLAYA.

In the 1907 edition of this book the Brahmaputra was regarded as a river of the Assam Himālaya and it is indeed their greatest river. But in 1907 the unsolved problems of the Himālayan Brahmaputra were still uppermost in our minds, and they led us to concentrate our attention too exclusively upon the Himālayan section of this river. In 1913 these problems were solved by Morshead and Bailey, and their solution has led us to take a wider outlook. Our realisation of the geographical importance of the Tibetan section of the Brahmaputra, so reverenced by the Tibetan people and so unique in the altitude of its long bed, prevents us in 1932 from classifying it with the rivers of Assam. Just as the Indus is the river of Ladākh and the Punjab, so is the Brahmaputra the river of Tibet, Assam and Bengal.

In this chapter the Tīsta has been included with the rivers of the Assam Himālaya but it is the river of Sikkim, and does not enter Assam. Sikkim is a Himālayan state and its area coincides with the Himālayan area drained by the Tīsta; it is situated at the junction of the Nepāl and Assam Himālaya, and separating the two belongs to neither. Some writers have referred to the mountains of Sikkim as the "Sikkim Himālaya", and it is quite correct to do so, but in this paper we have endeavoured for purposes of geographical classification to limit the numbers of Himālayan divisions, and as Sikkim is a small area, we have regarded the bed of the Tīsta as the eastern boundary of the Nepāl Himālaya and as the western boundary of the Assam Himālaya.

The Tīsta (Chart XXVIII).

The Tīsta has its sources in Tibet, and in the glaciers of Kānchenjunga. It flows across the plains of northern Bengal between the alluvial basins of the Ganges and Brahmaputra. The rainfall in Sikkim during the monsoon is at times very heavy, and the Tīsta has altered its course in Bengal many times during the deposition of the alluvium, out of which the plains have been built. It has even changed its course several times within the historic period. Formerly it joined the Ganges at Jāfarganj, but in 1787 it suddenly changed its direction and opened a new channel to the eastward, in which it has since flowed joining the Brahmaputra above Diwānganj.

The ancient Sanskrit names for the river were Trishna and Trisrota; the Kalili Purāna describes the Tīsta as flowing from the breasts of the Goddess Pārvati, wife of Siva.

The Great Himālayan range trends on a concave alignment from Kānchenjunga to Shudu Tshenpa: the Tīsta drains the concave bay in the range, and as

it has cut back through the mountains by head-erosion, many of its sources are now situated behind the crest-line.

Sir Joseph Hooker was the first traveller to discover that the Tīsta is draining a comparatively level valley in rear of the great granite range. "Above "11,000 feet", he wrote, "the valley expands remarkably, the mountains recede, "become less wooded and more grassy, while the stream is suddenly less rapid, "meandering in a broader bed and bordered by marshes". (*Himālayan Journal*, Vol. II, page 66).

"The upper portion of the course of the Tīsta (Lachen-Lachong) is materially "different from what it is lower down, becoming a boisterous torrent as suddenly "as the Tamur does above Mywa Guola. Its bed is narrower, large masses of "rock impede its course."

The Glaciers of the Tīsta.—The Tīsta has many glacial sources in the Great Himālayan range. Its most important glaciers are those on the eastern, north-eastern and south-eastern slopes of Kānchenjunga; the longest is the Zemu which has been estimated to be about 16 miles in length.

Kānchenjunga Mountain.

The history of the name Kānchenjunga was given in Chapter 3 of Part I, and an account of the controversies that have occurred over the name was also given. After Part I had been sent to press, Rai Bahadur Lobzang Chhoden, the Private Secretary to the Mahārāja of Sikkim, made an interesting contribution to the discussion in the Himālayan Journal (*Himālayan Journal*, 1932, p. 198). The Rai Bahadur wrote that Dr. Shastri's assertion of the Sanskrit origin of the name Kānchenjunga was based on Nepālese information, and he went on to say that "Kānchenjunga is essentially a Sikkim mountain". This is hardly an impartial description. For over 100 years Sikkim has been open to European travellers, whilst Nepāl has been closed, and the fame of Kānchenjunga has been due to European writers. But the high peak of Kānchenjunga cannot be said to be in Sikkim, nor can it be fairly claimed as a Sikkim mountain, for it is standing upon the border between Sikkim and Nepāl. The Sikkimese have a right to give their name to the mountain, but the Nepālese have a similar right.

The controversy over the name Kānchenjunga has been largely due to a difference of outlook: the geographers have endeavoured to adopt the name that is in modern use among the people, the etymologists have wished to trace the name back to its origin. The discussion in Chapter 3 of this book, and in the subsequent issue of the Himālayan Journal, seems to show that the name Kang-chen-dzo-nga was originally a Sikkimese name, and that it has only recently been adopted by the Tibetans of Tibet. The Chinese surveyors in Tibet never heard the name Kang-chen-dzo-nga; no British nor Indian surveyor nor explorer ever heard the name Kang-chen-dzo-nga used by the Tibetans of the

Tsangpo valley. Colonel Bailey writes that he spent six months in Tibet north of Kānchenjunga where the mountain was a prominent feature, and that the Tibetans called it Kangchen. The Sikkimese name seems to have been adopted in Tibet by the educated classes about 40 years ago, after it had been included in a European dictionary of the Tibetan language. Before that it does not seem to have been used there. Geographers adopted the name Kānchenjunga, because this name first entered geography from the side of India, and in India the mountain was called and pronounced Kānchenjunga. This Indian geographical name subsequently became attacked by etymologists, whose various versions of its origin have been given in Chapter 3. The fact that the great authority Jeaschke suggested two different Tibetan origins rather weakened the etymological case. He was evidently experimenting. The meanings of his two versions were "five receptacles of glacier ice" and "five kings of ice": his meanings were subsequently interpreted by Waddell and others, as denoting either five glaciers or five peaks. This was a mundane interpretation of a poetic idea. In the Himālayan Journal, 1932, the Private Secretary to the Mahārāja of Sikkim, wrote that the five treasuries of Kangchen consist not of snow nor ice, but of salt, gold, books, weapons and crops. This latter explanation is not only opposed to the etymological guesses about five peaks and five glaciers, but it resuscitates the idea of gold, which the Indians first introduced and which Colonel Waddell scornfully refused.

In Chapter 3 of this book it was suggested that the Indian and Tibetan forms of the name have diverged so widely in the course of their evolution that they cannot now be represented by one formula, and that they both deserve separate recognition in their different spheres.

The Sikkimese name for the mountain.

It has been difficult to give a full and coherent explanation of the Kānchenjunga problem, as the controversy over the name has been continuing, whilst this book was being written. This difficulty may, I fear, have given to my account a want of sequence, and may have led to repetitions. My aim has been to prepare a record that will be of use to the Survey, when questions are raised in the future. A mountain, so unique as Kānchenjunga, will continue to be of interest to the human race throughout future ages, and the mystery surrounding its name will remain after our contentions have ceased. One writer in the press has stated that the question of a name is of no great importance and that our controversies are rather a waste of energy. A name, it is true, may not be of interest to any great number of living people, but the interest that is taken in it, limited though it may be, continues to survive through future centuries. Of all the works of civilised man the most enduring are his geographical names; and this fact should be borne in mind when the name of a famous mountain is under discussion.

After Chapter 3 of this book had been sent to press, an important letter was contributed to the discussion by Mr. Van Manen, to whom geographers have been much indebted. Whilst he advocated the use of the Tibetan name upon maps, he showed that the Tibetan name did not enter geography from Tibet, but from Sikkim. The name though Tibetan did not originate in Tibet. Sikkim is a Himālayan country and is not part of geographical Tibet. In northern Sikkim there are 20,000 Bhotias, and their language Da-njong-ka is a Tibetan dialect. The Sikkimese name Gans-chhen-mdzod-lnga does not appear to have been known in Tibet proper, until the latter half of the last century when it came to be entered in dictionaries. Its first public appearance was in the dictionary of Dr. Jeaschke: Dr. Jeaschke did not travel in Sikkim; he wrote his dictionary in Ladākh (1866 to 1881) and he derived the name Gans-chhen-mdzod-lnga from the various reports of travellers in Sikkim. Sarat Chandra Das travelled through Sikkim to Lhāsa in 1884, and in his Tibetan dictionary he enumerated the 20 most important mountains in Tibet, the names of which he had learnt from the Tibetan authorities at Lhāsa. Kānchenjunga was not amongst them. In his own dictionary however Sarat Chandra Das, following Jeaschke, gave Gans-chhen-mdzod-lnga as a name for Kānchenjunga. The surmise is perhaps permissible that Sarat Chandra Das in 1884 brought Jeaschke's name for Kānchenjunga to the notice of the authorities at Lhāsa. Instead of speaking of "the Tibetan name" for Kānchenjunga, it will be more correct to call it "the Sikkimese name".

THE GEOGRAPHICAL FORM OF THE SIKKIMESE NAME.

The controversy has been partly due to the pronunciation of the name by the people of Sikkim. Mr. Van Manen has shown that in 1830 Captain Herbert, the Deputy Surveyor General, travelled through Sikkim and recorded the name as Kanching-jinga. Later travellers in 1836 and 1838 recorded the name as Kanxching-jinga and Kunching-jinga.

The sound 'jinga' seems to have been prevalent among the Sikkimese: the sound 'dzo-nga' was not recorded by any travellers, until linguists went there. It may be that the early travellers were in contact with Lecha people. The Linguistic Survey of India gives the number of Lepchas in Central Sikkim as 35,000 and the number of Bhotias in Northern Sikkim as 20,000. Sir Joseph Hooker was present at a Lepcha festival in lower Sikkim in 1848, "on the day, "on which offerings had been made from time immemorial by the Lepchas of "Sikkim to the genius of Kānchenjunga". A Tibetan Lāma presided over the gathering of Lepchas, and an invocation was sung to the mountain: it is curious to see that in one part of the invocation the word "jinga" was used without any connection with Kanchen. Dr. Campbell, the Superintendent of Darjeeling, wrote the invocation down for Sir J. Hooker (*Himālayan Journals*, Chapter XVI).

The different spellings of the Sikkimese name have been due to varying pronunciations, and they detract from the value of the so-called "colloquial"

form of the name; a "colloquial" from is of little value if it is not in use among the people.

The written form of the Sikkimese name for Kānchenjunga is Gans-chhen-mdzod-lṅga. This name is found in dictionaries, and is accepted by linguists. Mr. Van Manen quotes a note published by a Tibetan school-master and dated July 1930. The school-master is of the opinion that the Survey should on their maps spell the name of the Sikkimese mountain in its written form. In cases in England where colloquial names differ in spelling from their written forms, (Cirencester, Beaulieu, Stiffkey, Daventry), the Ordnance Survey of Great Britain always enters the written form upon its maps and not the colloquial form. Now that the Sikkimese name for Kānchenjunga has been definitely accepted by linguists and by Rai Bahadur Lobzang Chhoden, it should in future be shown upon maps of Tibet and Sikkim, and this name should I think be Gans-chhen-mdzod-lnga.

The Indian name Kānchenjunga should be retained on maps of India. The argument has been put forward that the name given to a mountain by the people living near it should be also adopted by the people living at great distances. Such a course would be natural in the case of a lake, but when a peak is so high, as to be visible from an area exceeding 200,000 square miles, the people living at a distance may devise their own name. The race of mountaineers that live on the slopes of Nanga Parbat have for centuries called their mountain Diamar: the people of Kashmīr and those of the north-east Punjab, who see this mountain from long distances, and who consequently regard it rather with admiration than with awe, call it by the classic name of Nanga Parbat.

From the accounts of residents I estimate the number of Sikkimese, who know and who use the Sikkimese name Gans-chhen-mdzod-lnga, to be less than 5,000. In the plains of India I estimate the number of people, who know and use the Indian name Kānchenjunga, to be considerably more than 100,000, and possibly over a million.

The long line of Himālayan snow peaks *visible from the plains of Northern India*, though situated in different Himālayan countries, are inter-related, and by the Sanskritisation of Kānchenjunga the people of Bengal have brought that name into harmony with other Himālayan names that were also bestowed upon peaks by distant dwellers, with Dhaulāgiri of Nepāl, and Trisūl of Kumaun, with Jaonli and Bandarpūnch of Garhwāl and Nanga Parbat of Kashmīr.

Summary of conclusions.—The name Kānchenjunga should be used on maps of India and Bengal: the name Gans-chhen-mdzod-lnga should be used on maps of Sikkim and Tibet.

The Lesser Himālayan Ranges in Sikkim.

In Chapter 24, in the 1907 edition of this book, the opinion was expressed that "The Lesser Himālayan range and the Siwālik range seem to be absent from

"the basin of the Tīsta". Subsequent surveys and the re-drawing of maps by the Survey of India have however led to a change of view respecting the outer Himālaya ranges of Sikkim.

The Himālayan area in Nepāl is a wide zone crowned by a long snowy crest-line and traversed by outer and lesser ranges running parallel to the range of snows. The rivers have cut gorges through the lesser ranges. In the days before the introduction of contours into maps of the Himālaya the transverse lines of the deep valley-beds were more in evidence than the longitudinal ranges traversing the drainage. The beds of the rivers were definite continuous lines, the alignments of the ranges were indefinite and broken by gorges. The draftsman drew the river valleys accurately upon his map, and then filled in the hill-shading of ranges and spurs between the arms of the rivers. As was pointed out in 1907, the method of shading then in vogue gave too great an emphasis to the lines of the rivers, and subordinated the longitudinal ranges to the transverse water-partings.

Those who realise the difficulties attending generalization in any branch of science will sympathise with the map-draftsmen who have to discover the original governing lines of mountains. Even a surveyor in the field can never obtain a bird's eye view of the whole mass, and even he, in his generalization, is apt to attach an exaggerated importance to the rivers. On maps the water-partings were formerly the most conspicuous mountain-ranges: when two streams had been accurately plotted on a map, the draftsman had to draw a range between them. In nature the mountains have determined the directions of rivers, in maps the rivers have too often determined the directions of mountains. The introduction of the system of contours during the last 25 years has resulted in more emphasis being given upon maps to the structural lines of mountains and less emphasis to the water-parting lines.

In 1907 Sikkim was a well-surveyed area shown upon maps between the vague unsurveyed areas of Nepāl and Bhutān. The western boundary of Sikkim followed the long Singālila ridge which ran southwards from Kānchenjunga to the plains of Bengal and which had become well known in geographical literature. The eastern boundary of Sikkim followed another spur which ran southwards from the peak of Pauhunri and which was called the Dongkya range. From a political point of view the so-called Singālila range and Dongkya range were very important, but from a Himālayan point of view too great a topographical emphasis was given to them upon maps.

The introduction of contours upon maps has shown that these so-called "ranges" are probably nothing more than long spurs carved out of the great range by river drainage.

The introduction of contours has led to the belief that the long Mahābhārat and Siwālik ranges of Nepāl do trend across the basin of the Tīsta. The longitudinal courses of the Ramman and Great Rangit tributaries of the Tīsta are

probably due to their interception by the Mahābhārat range, and their junction with the Rangpo in southern Sikkim may have also been brought about by this range. Darjeeling (7,163 feet) and Senchal (8,599 feet) are probably on the Mahābhārat range.

The Himālayan rivers of Bhutān and Assam.—Although our knowledge of the Assam Himālaya has been considerably increased since the first edition of this book was published in 1907, they are still the least known portion of the Himālaya Mountains.

The principal rivers of the Assam Himālaya are from west to east,

1. Amo Chu
2. Raidāk
3. Sankosh
4. Manās
5. Bhareli
6. Subansiri
7. Dihāng
8. Dibāng
9. Luhit (Zāyul).

Of these 9 rivers the first four are in Bhutān, and are drawn (but not all named) in Chart XXIX, and the last five flow through the Assam Frontier Tracts and are shown in Chart XXX.

The name Dihāng is applied in the Himālayas to the great river, which is known as the Brahmaputra in India, and as the Tsangpo in Tibet.

Major H. R. C. Meade who was in charge of the survey operations carried out in Bhutān in connection with Colonel F. M. Bailey's expedition in 1922, has classified seven of the rivers of Assam according to their volumes of water on emergence from the hills. The following is his classification :—

1. Dihāng, the Himālayan river that connectes the Tsangpo of Tibet with the Brahmaputra of Assam.
2. Manās
3. Luhit
4. Sankosh, (known as Mo Chu in Bhutān)
5. Subansiri
6. Dibāng
7. Bhareli.

The two westernmost rivers Amo Chu and Raidāk could not be included in this classification.

The Raidāk-Sankosh rivers.

In Chart XXIX is shown the Himālayan area drained by the Raidāk, and the several rivers are drawn that have been grouped under the name Raidāk.

It will be seen from the chart that three of these rivers, all of which are important, emerge from the hills independently of one another and that they join the Brahmaputra in the plains independently of one another. These three rivers are :—

(*a*) the Amo Chu on the west draining the Chumbi valley; under the name of Torsa it joins the Brahmaputra at Alipur.

(*b*) the Raidāk in the centre with its sources on Chomo Lhāri; it joins the Brahmaputra at Kurigram.

(*c*) the Sankosh on the east draining the western slopes of Kula Kangri: it joins the Brahmaputra at Patamari below Dhubri.

In 1907 the names of these rivers were doubtful: the expedition of Colonel Bailey and the surveys of Major Meade in 1922 showed that the largest of these three rivers is the Sankosh. (*Records, Survey of India,* Vol. XXI). As the Amo Chu, the Raidāk and the Sankosh flow independently of one another from the snows to the plains it would perhaps have been more in keeping with the map of the Tīsta (Chart XXVIII), if we had given to each of them a separate drawing instead of combining them into one map. But the question is an open one. In the 1907 edition of this book we wrote :—" The interesting feature in the geography of the Raidāk is " that the hill rivers flow out independently parallel to one another and perpendi- " cularly to the ranges, instead of combining behind one of the outer ranges to force " a joint passage. The reason of this peculiarity is that the outer Himālayan and " Siwālik ranges are not represented by any marked chains of mountains in the " basin of the Raidāk." Major Meade writes, " The Amo Chu, Raidāk and " Sankosh all break up into several channels in the plains, and join each other, " so the three may be looked upon as a single basin ". The lower map on Chart XXIX was named after the central river of the three, the Raidāk: but the easternmost river Sankosh is the longest and largest of the three. Major Meade writes, " In its volume of water the Raidāk is less than half the size of the " Sankosh, and the Amo Chu (Torsa) is about one-third, where they leave the hills. " The Sankosh drains the whole of the Great Himālaya Range between Chomo " Lhāri (23,997 feet) and Kula Kangri South peak (24,740 feet). The various " tributaries of the Sankosh unite near Punaka (5,000 feet): below Punaka " the river bed is a quarter of a mile wide, but below Wangdupotrang (4,500 feet) " rock outcrops confine the river to a precipitous gorge ". The area drained by the Amo Chu, Raidāk and Sankosh is known in geography as Western Bhutān. The following further reference to the Sankosh-Raidāk basin is of geographical interest and is quoted from Major Meade's notes :—

" The Amo Chu is known at its head-waters as the Chumbi valley, and it " rises in the Tang La (15,000 feet) which is an abnormally low pass on the Great " Himālayan divide between the Pauhunri peaks of North Sikkim and the Chomo " Lhāri group north of Bhutān. The trade-route from Lhāsa to India passes over " the Tang La."

"But from Chumbi, which is a wedge of Tibetan territory between Sikkim "and Bhutān, the trade-route bifurcates, one road leading to Darjeeling over the "Natu La (14,500 feet) and the other to Kalimpong over the Jalap La (14,500 "feet). These two roads are diversions. The natural avenue from Tibet to "India is down the Amo Chu valley through Bhutān, and it would not be diffi-"cult to make a motor road from the Indian rail head at Dalsingpara up the Amo "Chu to Chumbi and thence on to Gyantse and the Tsangpo river: at present "loads have to be carried up by pack or cooly transport."

The Manās (Chart XXIX).

Unlike the Raidāk-Sankosh the river Manās is formed by the union of several Himālayan rivers, which converge and unite in the mountains in rear of an outer Himālayan range. The name Manās is given to the river in its course across the plains of Assam, but this name is not used in the hills of Eastern Bhutān.

In 1891 Colonel Tanner of the Survey of India wrote, "In Bhutān all the "rivers can be set down as unknown, except the Lhobrak of Tibet, which emerges "into India as a part of those large rivers, which united form the Manās of the "plains".

The name Lhobrak (or Kuru Chu) is applied by the Bhutānese and Tibetans to the main central tributary of the Manās (Chart XXIX). The Lhobrak rises on the north-west slopes of the Kula Kangri group, and after following a semi-circular Trans-Himālayan course it breaks through the Great Himālayan range at Thunkar just south of Lhakhang Dzong: Meade writes that the height of the bed of this gorge is 10,000 feet. "This gorge," he says, "is impassable, "and the southward routes from Tibet have to cross the Himālayan range both "east and west of the gorge by passes that are over 15,000 feet high".

The Lhobrak is the only tributary of the Manās that rises on the northern side of the Great Himālaya, and that pierces the latter by the gorge of Thunkar, but three lesser though important tributaries the Mati Chu, the Dangma Chu and one other rise on the southern side of the Himālaya and combine with the Lhobrak, in south-eastern Bhutān, to force a passage through the outer range.

The river Bhareli (Chart XXX).

The Bhareli is a small river of the outer hills: its triangular basin is fitted in between the greater basins of the Manās and Subansiri. The Bhareli drains the Aka country and the eastern portion of the Dafla hills.

The Subansiri (Chart XXX).

At one time the Subansiri was supposed to be the continuation of the Tsangpo of Tibet. But Colonel Woodthorpe of the Survey of India who penetrated the mountain basin of this river in 1877, pointed out that its volume of water was only one-fourth that of the Dihāng.

Owing to the long-continued controversy over the Brahmaputra and Tsangpo the Subansiri has come to be regarded as a Himālayan tributary of the Brahmaputra, and even in Chart XXX of this book it is still shown in combination with the Brahmaputra. Such a combination is due to past geographical controversies. Though the Subansiri is a tributary of the Brahmaputra in the plains, it is not a Himālayan tributary, and though it is not incorrect to include it in Chart XXX, it is as independent of the Himālayan Brahmaputra as the Manās is. In Chart XXIII the Manās is given a separate basin, and it would perhaps now have been more consistent to separate the Subansiri in a similar way. After emerging from the hills the Subansiri flows across the plains for 100 miles before it joins the Brahmaputra.

It is probable that the Subansiri is draining both the southern and northern sides of the Great Himālayan range for a length of 120 miles; it is believed to have a long Trans-Himālayan course, but our present knowledge of this river is uncertain. Colonel Woodthorpe wrote, "The Subansiri is a noble river in the "hills and the gorges through which it emerges into the plains are singularly fine: "the banks are formed of precipitous masses of rock enclosing deep pools in which "measurements give a depth of 70 and 80 feet: the river is 70 yards broad at "Ganditula and flows with great velocity".

In the outer Himālaya the Subansiri separates the Miri hill tracts from those of the Abor.

The trijunction of rivers at Sadiya.

Three large rivers unite at Sadiya in Upper Assam: they are the Dihāng, the Dibāng and the Luhit (Chart XXX). The united river below the point of junction is called the Brahmaputra: the name Brahmaputra begins at Sadiya. The Dihāng is the Himālayan Section of the Brahmaputra, and it is the channel by which the water of the Tsangpo of Tibet reaches the Brahmaputra.

The Dibāng and the Luhit are tributaries that join the Brahmaputra in the plains, and that are classified now as independent rivers of the Assam Himālaya. The Dibāng drains the Himālaya area east of the Dihāng basin, and the Luhit, known also as the Zāyul, is east of the Dibāng. The Luhit (Zāyul) is the easternmost feeder of the Brahmaputra, and drains a large basin between Assam and Burma. The Abor tribes live west of the Dihāng, the Mishmi tribes live east of the Dibāng.

In the winter of 1878 Captain Harman, R. E., measured the volumes of water discharged by the four principal rivers of Upper Assam at the places where they emerge from the Himālaya. He obtained the following results:—

Discharge of the	In cubic feet per second.
Dihāng (Brahmaputra)	55,500
Luhit	33,800
Dibāng	27,200
Subansiri	16,900

THE "SOUTHERN TIBET WATERSHED".

The "Southern Tibet watershed" extends from Lake Mānasarowar to the Himālayan gorge of the Dihāng (that is from longitude 82° to longitude 95°). That this watershed is a real mountain range cannot be questioned; near Mānasarowar its peaks are high, and its glaciers large: Hayden found north of Sikkim that it was composed of granite.

But north of Nepāl it is not an imposing feature, and north of Mount Everest Morshead described it as insignificant. Its first claim upon our attention arises from the fact that though its magnitude is relatively small, standing as it does between the greater masses of Himālaya and Trans-Himālaya, its continuity is as persistent as that of Himālaya itself. Its second peculiarity and one that has enhanced its importance in geography is, that it is the Himālayan watershed. The early geographers were surprised at discovering that this low range was the watershed of the Gangetic basin: the numerous rivers of Oudh and Nepāl and Sikkim and Bhutān and Assam have all cut gorges back through the giant range of Himālaya, but no one of them has been able to cut a gorge through the dwarf range standing behind.

In Chart XXX the Himālayan watershed is shown from longitude 82° to 92°, but east of 92° this watershed has not been drawn, because the Subansiri river has been regarded as belonging to the Brahmaputra. Recent explorations have brought home to us the lesson that the Subansiri is no more a Himālayan tributary of the Brahmaputra than the Tīsta is, or the Raidāk, or the Manās, for all these rivers join the Brahmaputra in the plains. There seems little room for doubt that the same persistent Himālayan watershed continues all along north of the Subansiri.

The Great Himālayan crest-line has not as yet been traced from the Kula Kangri peaks of Bhutān to Namcha Barwa. If our representation of the upper Subansiri on Chart XXX is correct, the Great Himālaya must bend sharply to the north-east in longitude 94°. It is an open question at present whether the Himālaya makes this sharp bend in 94°, or whether it follows a gentle curvature from 92°. If it is found to bend sharply at the Subansiri in 94°, the long high promontory of Namcha Barwa will inevitably be compared by geographers with the similar promontory of Nanga Parbat that projects northwards from the Himālaya in Kashmīr (longitude 75°, see Chapter 25). There is a strong resemblance between the knee-bend of the Indus north of Nanga Parbat and the curve of the Tsangpo north of Namcha Barwa (Charts XXX and XXXIV).

It will be noticed that throughout this discussion of the "Southern Tibet "watershed", we have been hampered by the fact that as a range the watershed is nameless, notwithstanding its importance and its continuity.

The absence of a suitable name for this watershed range has become a serious difficulty in Tibetan geography (see Chapter 12). In the 1907 edition of this book we used the name "Ladākh range". But a name, properly chosen ought to be acceptable to the local Tibetans, and there is no prospect of the Tibetans of Eastern Tibet adopting a name like Ladākh that is the name of a rival province, 800 miles distant; there is no more prospect of their doing this, than there would be of the English people of Kent calling their downs the Hampshire downs.

When in 1884 the name "Ladākh range" was first introduced by geographers in Western Tibet, it was not foreseen that this range might pass beyond Mānasarowar and might even extend to the eastern limits of Tibet.

Since 1907 a scientific objection to the name "Ladākh range" has come to be realised. From Mānasarowar eastwards through Nepāl and Bhutān the principal characteristic of this range is that it is the Himālayan watershed. But north-westwards from Mānasarowar it is no longer the Himālayan watershed. This change in its character and in its place in geography is due to the vagaries of drainage. East of Mānasarowar the Himālayan rivers rise behind the main Himālayan range. But in the Punjab Himālaya the Chenāb and the Jhelum have their sources in the Himālayan crest.

In Chapter 12 of this book the range has been called the "Nepāl-Tibet watershed", (see frontispiece chart, Part I). It could not be named the "Himā-"layan watershed" for reasons explained above; it could not be named the Indo-Tibet watershed because the Brahmaputra of India receives the drainage of all Southern Tibet. Further consideration has shown that of all the names suggested for this range, the most suitable will be "Southern Tibet watershed". This last name will be preferable to Nepāl-Tibet watershed.

Range-Bifurcations, and Conjunctions.

In Chapter 12 it has been suggested that the long Ladākh range of Tibet may eventually conjoin with the Karakorum range through the Haramosh ridge. In Chapter 21 there are references to the bifurcation at Dhaulāgiri of the Nāg Tibba range from the Himālaya. There are other references to "conjunctions" and "bifurcations" of ranges in this book. As these questions are being considered now for the last time, the opportunity is taken of explaining that "conjunctions" and "bifurcations" may possibly mean the same thing. The employment of the two words is a question only of relativity. If we are examining the mountains of Southern Tibet from east to west, and we find that at Dhaulāgiri the Himālaya range has separated into two branches, we call the minor branch a "bifurcation"; and further west when we find the Ladākh range joining the

Karakorum range at Haramosh we use the word "conjunction", only because we ourselves have been moving westwards. If we had started in the west and had moved in the opposite direction, we should have regarded the Ladākh range at Haramosh as a "bifurcation" of the Karakorum, and in Nepāl we should have discovered that the Nāg Tibba range was trending into "conjunction" with the Himālaya. It is possible that geologists may in the future discover fundamental differences between bifurcations and conjunctions, but as far as geographers are able to judge, the difference is one of outlook.

The only law that seems to hold is that if the map student moves from east to west the Himālaya frequently bifurcates (Nāg Tibba, Zāskār, Dhaula Dhār, Pīr Panjāl), and the Karakorum forms conjunctions (Sasir and Haramosh): whereas if the student moves from west to east, the Karakorum bifurcates, and the Himālaya forms conjunctions.

CHAPTER 23.

THE BRAHMAPUTRA.

The basin and tributaries of the Brahmaputra are shown in Chart XXX: this river rises near the sources of the Karnāli and Sutlej in Tibet at a height of 16,000 feet. Unlike the Indus, or Sutlej, or Karnāli, it has cut no deep channel for itself in Tibet, and in spite of its immense elevation it is, south of Lhāsa, a sluggish and navigable river. Its basin is nowhere in contact with that of the Indus. Its bed is 14,840 feet high at Tradom, 11,800 feet at Shigatze, 8,000 feet at Gyala Sindong and 442 feet at Sadiya in Assam.

Change in direction of flow.—The remarkable feature of the Brahmaputra in Tibet is the tendency of its feeders to flow in a direction opposite to that of the trunk river. If but one feeder had been observed to take a course contrary to that of the river, the phenomenon might have been attributed to some local topographical peculiarity; but when all the principal affluents of a long section of the river are found to follow the same contrary course, it becomes evident that the Brahmaputra must at no distant time have flowed from east to west in Tibet, and that its tributaries were developed during that period of its history.

It has been held by some authorities that the Brahmaputra has been diverted from an original course through China, and has been forced to cut a passage through the Assam Himālaya. But in our opinion the evidence furnished by its feeders is conclusive; the Brahmaputra formerly flowed through Tibet from east to west. It is not possible to express an opinion at present as to where it escaped through the Himālaya: it may have flowed over the Phuto pass and through the defile of the Kāli Gandak; it may have passed through the basin of the Karnāli, and it may have followed the present Himālayan course of either the Sutlej or the Indus: arguments can be adduced to show that each of these hypotheses is worthy of future investigation, but with our present knowledge no conclusion can be reached.*

---

* The following evidence supports the idea that the Brahmaputra once escaped from Tibet along the present course of the Kāli Gandak. The Phuto pass separating the basin of the Kāli Gandak from the present basin of the Brahmaputra is an extraordinary depression in the Ladākh range and is only 250 feet higher than the Brahmaputra plains of Tibet. The gorge of the Kāli Gandak intersecting the great Himālaya is immensely deep and can hardly have been cut by the volume of water issuing from so small a catchment basin, as the river now possesses behind the great Himālaya.

That the Brahmaputra once flowed out from Tibet by the channel of the Sutlej is an hypothesis that helps to explain the present existence of the great canyon in Tibet; the small stream that now trickles along the floor of the canyon cannot have sufficed to cut such a mighty ravine. The course of the Sutlej in Tibet follows the same alignment as that of the Brahmaputra, and the channels of the Spiti and the Chenāb are further extensions of the same line.

The belief that the Brahmaputra was formerly an affluent of the Indus in Tibet rests only upon the great depth to which the Indus has cut down its bed in Tibet. The bed of the Sutlej at its exit from Tibet is 10,000 feet high, that of the Brahmaputra is 8,000 feet, but that of the Indus is only 4,600.

The suggested explanations of the former course of the Brahmaputra are the merest conjectures; it will be noticed that they all depend upon the tacit assumption that existing streams cannot have accomplished the work of erosion that has been accomplished. We possess however no sufficient data upon which to build estimates of the eroding power of streams acting through millions of years, and seeing that Tibet once possessed a moist climate, we are not warranted in assuming that the volume of water discharged by rivers has never been larger than at present.

Of the great rivers of the world, the Brahmaputra furnishes the only instance of drainage flowing in a diametrically opposite direction to what it formerly did, though still occupying the same bed.

The principal Tibetan tributaries of the Brahmaputra, that may be observed to flow against the present river, are :—

(1) The Kyi, or Lhāsa river.
(2) The Nyang, joining the Brahmaputra at Shigatze.
(3) The Rang.
(4) The Shang.

Many smaller feeders adopt contrary courses also.

The most recent maps show that shortly before their junctions with the Brahmaputra, these tributaries are beginning to bend in their courses, and to turn towards the present direction of the Brahmaputra's flow, and in their future development they will doubtless adapt themselves to the altered conditions.

The Nyang tributary.—The Nyang tributary rises in the Yu lake north of Chomo Lhāri, forces its way through the Southern Tibet watershed range, and falls into the Brahmaputra near Shigatze. It is the only Tibetan tributary of the Brahmaputra that drains the Great Himālayan range, and the only one east of Mānasarowar that pierces the Southern Tibet watershed range. The peculiar bay, which is to be noticed in the water-parting on Chart XXX, west of Chomo Lhāri, is due to the passage of the watershed range by the Nyang river. The Arun, the Kāli Gandak, the Bheri and others rise in the watershed range and pierce the great Himālaya, the Nyang rises in the great Himālaya : the Nyang has broken the continuity of the watershed range and has made the Himālaya itself the watershed at this point. Near the sources of the Nyang Chu lies the basin of the Kala and Hram lakes (14,700 feet) which are connected with each other and which may once have formed the head waters of the Nyang Chu, from which they are separated by an imperceptible divide, only a few feet higher than the surface of the lakes.

The great lake of Yamdrok and the lakes of Trigu, Pa Dzo, Dumo and Pomo are situated between the Tsangpo river and the Great Himālayan range : they form the South-Eastern Tibet Lake basin. Major Meade writes, "The most striking features of this area are the rounded easy gradients of "the hills, which are rideable almost everywhere, and the extremely low divides "between the various drainage basins. It is probable that in recent geological "times the first four lakes mentioned above formed part of the Rang river, while "the Pomo Tso was a tributary of the Nyang river. It is noticeable that the "trend of the drainage is from east to west, which tends to support the conten- "tion that the Tsangpo (or Tibetan portion of the Brahmaputra) flowed west- "wards in its present channel."

The source of the Brahmaputra

In the controversies over the source of the Ganges during the early part of the last century it became difficult to define exactly what was meant by the word "source". The Ganges had many sources, and no agreement could be reached as to which of them was the true source. But the case of the Brahmaputra is different: its Trans-Himālayan portion is 1,000 miles in length, and it would not be possible therefore to contend, as in the case of the Ganges, that the sources of the Brahmaputra were in Himālayan glaciers. The Brahmaputra leaves Tibet and enters the Himālayas near the peak of Namcha Barwa, and the gorge through which it escapes from Tibet is 1,000 miles east of its Tibetan source near lake Mānasarowar.

Ryder made a survey of the upper Tsangpo Valley and of the Tsangpo-Mānasarowar watershed in 1904, and this survey was the first step that had been taken to solve the question of the source. Ryder was surveying in the winter, when the upper reaches of the Tsangpo were frozen, and it was difficult then, when no water was flowing in the several streams to determine their relative importance. In June 1907 when water was flowing in these branch rivers, Sven Hedin thoroughly explored the principal sources of the Tsangpo.

He has given an account of these explorations in Chapter XXXVII of Vol. II, *Southern Tibet,* and has explained his differences from Ryder. Ryder's map showed the main features correctly, but not the sources which had been under ice and snow. Sven Hedin followed the streams to their sources and measured their volumes of water. At Charok (Ryder's Chiru, height 15,275 feet), Hedin measured the Tsangpo not very far from its sources; its breadth there was 47 metres, and its average depth 1 metre. Above Shamsang he discovered that the Tsangpo was fed by three branches, the Chema Yundung, the Kubi Tsangpo and the Maryum Chu. The problem he set himself to solve was, which of these three branches was the real and primary source of the Brahmaputra. He measured their volumes of water in cubic metres per second, and found that the volume of the Kubi Tsangpo was 3½ times greater than the combined volumes of the Chema Yundung and Maryum Chu taken together. The Chema Yundung is a few miles longer, than the Kubi Tsangpo, but the volume of water in the Kubi is overwhelming; and Sven Hedin writes, "All who in future see both "these rivers will agree with the Chinese and Tibetans, as I did, and will call "the Kubi Tsangpo the source of the Brahmaputra".

There are several glaciers in the Kubi Gangri mountains that flow into the Kubi Tsangpo; the Aksi and the Ngamo-dingding glaciers are 7 miles in length, the Langta-chen may be longer.

The northern watershed of the Tsangpo.—In the 1907 edition of this book the northern watershed of the Tsangpo could not be shown with certainty, and Sven Hedin discovered errors in it between longitude 84½° and 89° (*Southern Tibet,* Vol. II, page 290). Between these meridians he crossed the watershed in five

places; he writes that he could only sketch it roughly. In Chart XXX the northern watershed of the Tsangpo has been re-drawn, and though it is more correct now than in 1907, it is still in places conjectural. As was explained in Chapter 14, the supposed continuity ot the Kailās range north of the Tsangpo cannot now be maintained. Several short parallel mountain ranges of Trans-Himālaya appear to trend obliquely *across* the linear alignment which we had formerly adopted for the Kailās range, and all pursue south-easterly courses *towards* the Tsangpo: there are the Ding La range, the Pedang, the Surla, the Lunkar and Lunpo Gangri; the longest are the Kanchung Gangri and the Lapchung Gangri which bend round from south-east to north-east, and which follow semi-circular alignments such as are unknown in the Himālayas.*

In 1907 we assumed that the range north of the Tsangpo belonged to the same orographical system of parallelism, as the ranges south of the Tsangpo. But Hedin's explorations in Trans-Himālaya have shown that the trends of the ranges north of the Tsangpo do not conform to those south of the river; the line of the river appears now to be a natural boundary line between two different orographical systems.

East of the Lapchung range the Nyenchen-tang-lha trending to the north-east (in conformity more with Trans-Himālaya than with Himālaya) becomes the northern watershed of the Tsangpo; it is however pierced by the Mu Chu which rises behind it in Trans-Himālaya. The Kyi Chu, (the river of Lhāsa, and the most important tributary of the Tsangpo), drains the north-eastern section of the Nyenchen-tang-lha.

The Southern Tibet watershed.—In Chapter 12 the Ladākh range was divided south of Mānasarowar into a western and eastern section, and its eastern section was tentatively named the "Nepāl-Tibet watershed". This range is the southern watershed of the Tsangpo. A footnote was subsequently added to Chapter 12 in order to explain that the name "Southern Tibet watershed" would be preferable to the name "Nepāl-Tibet watershed". Although this watershed range is the divide between the rivers of Nepāl and the Tsangpo river of Tibet, the political boundary between Nepāl and Tibet does not follow the watershed. The name "Southern Tibet watershed" would be free from this objection. The source of the Tsangpo is in the mountain chain known to Tibetans as the Kubi Gangri, and the Kubi Gangri are the western termination of the Southern Tibet watershed.

The position and alignment of the Southern Tibet watershed, though determined approximately by early survey-explorers, were first surveyed in 1904 by Ryder after the Lhāsa expedition. The only important change in this watershed introduced by the Nepāl Survey of 1927 was in the Tsangpo-Gandak section, (Chart XXX).

* *Southern Tibet,* VII, plate LXXXIX.
Southern Tibet, Map of Eastern Turkestan and Tibet, Sheet XIV, scale one million.

In Chapter 22 the easterly extension of the range that constitutes the Southern Tibet watershed has been considered. The unbroken alignment of this range can be traced in rear of Nepāl and Sikkim, but after passing behind Sikkim it is breached by the river Nyang Chu. Beyond the Nyang Chu the same range has been traced north of Bhutān by Meade; it is visible too as the watershed between the Tsangpo and Subansiri. Whether this long and persistent "Southern Tibet watershed" is continued east of the Dihāng is a problem that can only be solved by future explorations.

The Himālayan section of the Brahmaputra.—East of the Kyi Chu (Lhāsa) the additions to our knowledge of the Tsangpo have been mainly gained (see Chapter 10) from the explorations of Bailey and Morshead 1912-13 and from those of Kingdon Ward (1924 and later). The surveys of Bailey and Morshead in 1912-13 brought to light serious errors in the representation of the Himālayan section of the Brahmaputra upon maps. Prior to 1912 we had shown the Tsangpo as changing its direction from Tibet into the Himālaya in longitude 94°: Morshead however fixed the knee-bend of the river 65 miles further east in longitude 95¼°.

The great river, that is called "the Tsangpo" north of the Himālayas, and the "Brahmaputra" south of the Himālayas, bears the name of the "Dihāng" throughout its intermediate and Himālayan section. The Tsangpo has glacial sources in the Kubi Gangri, the Trans-Himālaya and the Nyenchentang-lha. Nothing is known of the Himālayan glaciers that flow into the Brahmaputra with the exception of those discovered by Bailey and Morshead on the slopes of Namcha Barwa, the largest of which was the Sanlung (Chapter 10).

The falls of the Brahmaputra.—Morshead in his report referred to "the falls of the Brahmaputra", and to their description by the Sikkimese explorer Kinthup, who reached them in 1880. "Kinthup's description of this country", Morshead wrote, "is in general quite accurate. Referring, however, to Pemakochung, he makes the following erroneous statement: 'The Tsangpo is two chains distant from the monastery, and about two miles off, it falls over a cliff called Sinji-Chogyal from a height of about 150 feet. There is a big lake at the foot of the falls where rainbows are always observable.' Actually, the falls near Pemakochung, to which the Tibetans have not given a name, are only some 30 feet in height, though it is true that a rainbow is visible on sunny days in the spray which is thrown up in immense clouds. On the other hand, falls called Sinji-Chogyal (Shingche Chogye) of approximately 150 feet do actually exist on the small side stream which, rising below the Tra La, joins the Tsangpo opposite Gyāla."

The Siyom tributary.—The Siyom tributary joins the Dihāng (Brahmaputra) 20 miles above the place where the latter enters the plains. It drains a small mountain area of about 2,000 square miles bordering the Dihāng on the

west. The village of Yembung is situated near the junction of the Siyom and Dihāng. As it is a Himālayan tributary of the Dihāng, it would be incorrect to classify it as one of the independent rivers of the Assam Himālaya. It has been shown (without a name) in Chart XXX. On the Survey of India Sheet, dated 1928, on the scale of two-million it is also shown nameless. "The Siyom valley", Major Meade writes, "has a particularly heavy rainfall."

The Tsangpo and the peak of Namcha Barwa.—After its long course from west to east through Tibet the Tsangpo changes its direction when it is 100 miles west of the high peak of Namcha Barwa (25,445 feet) and thenceforward it flows on a north-easterly course towards the peak; it encircles Namcha Barwa on the west and north and east, and then turning south it cuts a gorge across the Great Himālayan range.

The following passage is quoted from the 1907 edition of this book:

"The Sutlej in issuing from Tibet pierces the border range of mountains "within 4½ miles of Leo Pargial, the highest peak of its region: the Indus when "turning the great Himālayan range passes within 14 miles of Nanga Parbat, "the highest point of the Punjab Himālaya; the Hunza river cuts through the "Kailās range within 9 miles of Rakaposhi, the supreme point of the range. It "will form an interesting problem for investigation whether the Brahmaputra of "Tibet has cut its passage across the Assam Himālaya near a point of maximum "elevation."

In 1913 Colonel Morshead had an opportunity of investigating this problem, and he reported as follows:

"Our examination of the Tsangpo gorge enabled us to prove definitely "that this was another striking example of the extraordinary feature of Himālayan "Geography first noted in 1907, namely, that when a Tibetan river cuts through "the Himālayan range, it almost invariably selects the very highest portion of "that range, through which to pierce its gorge."

CHAPTER 24.

THE RIVERS OF THE PUNJAB HIMĀLAYA, AND LAKE MĀNASAROWAR.

The Punjab Himālaya is the name given to that portion of the great range which is drained by the five rivers of the Punjab, the Sutlej, the Beās, the Rāvi, the Chenāb, and the Jhelum. A separate chapter will be allotted to the river Indus. The relationship of Lake Mānasarowar to the river Sutlej has been a problem studied by many distinguished explorers, and it has been necessary to refer to it in this chapter.

The Sutlej.

Sutlej is the Indian name for the ancient river Shatadru (or Sutudri) which was described in the Vedas as "flowing in a thousand channels." It was called Zaradros by the ancient Greek historians, and by Ptolemy the Egyptian geographer. To the Dogras of the Himālayas the river is known at the present day as the Sutluda.

Narrowness of its basin.—The mountain basin of the Sutlej (Chart XXXI) lies mainly north of the Himālaya; the area of the Himālaya proper drained by this river, between the great range and the plains of India, consists of an insignificant transverse strip, and it is an interesting problem to study how it can have come about that such a river drains such a narrow zone in its Cis-Himālayan course.

The Sutlej is bounded on the east by the water-parting of the Giri (Jumna) and on the west by that of the Beās: at corresponding points in the mountains the beds of the Giri and Beās are relatively higher by 600 or 700 feet than that of the Sutlej, so that the latter is running along a deeper trough than the rivers on either side of it. Increased depth of trough means steeper slopes, and steeper slopes give to the tributary streams greater erosive power. The mountains should therefore be more rapidly denuded by the feeders of the Sutlej than by those of the Giri or Beās, and the basin of the Sutlej in the outer Himālaya should now be slowly widening,—the eastern water-parting retiring towards the Giri, the western towards the Beās. The fact that the Sutlej has no Cis-Himālayan tributaries comparable to those of the Jumna or Beās tends to show that it is the youngest river of the three. Whether these speculations are correct or not, the question as to how the Giri and Beās have confined their giant neighbour to a trough less than 20 miles wide remains worthy of consideration.

The Sutlej rises in the distant high-lands of Tibet, and possesses a very long course through the mountains. The Trans-Himālayan portions of its basin, however, receive but little rain, and table XIV of Chapter 19 shows its annual discharge to be small.

Much of the rainfall in the higher Himālayan valleys is said to be due to moist winds rushing up the mountain passages cut by the rivers. The rain-bearing winds of the monsoon blow from the Bay of Bengal across the Gangetic plains, and the valley of the Sutlej, lying as it does at right angles across their path, is not favourably placed for their reception.

Lake Mānasarowar.

The problems connected with Lake Mānasarowar have been under the consideration of geographers for over a century and have been investigated by many explorers. In this book it is not possible to give a complete history of the several explorations, and it has been necessary to omit references to many interesting journeys and to mention only such as have contributed to the conclusions accepted to-day. The main question at issue divested of secondary details has been whether Lake Mānasarowar is a source of the river Sutlej or not; if this question can be answered, the subsidiary problems can be solved also.

It has sometimes been asked,—why such a simple problem should have attracted so much attention, and why should its solution be regarded as important? Lake Mānasarowar is famous in Hindu mythology; it had in fact become famous many centuries before the Lake of Geneva had aroused any feelings of admiration in civilised man. To the north of Mānasarowar stands the sacred peak of Kailās, reverenced in Sanskrit literature as the paradise of Siva. Before the dawn of history Mānasarowar had become the sacred lake, and such it has remained for four milleniums. Its inaccessibility has enhanced its sanctity, and has enshrouded it in mystery.

From the geographical point of view the problem of Mānasarowar is not an isolated one, and the methods of solution adopted for it will be followed in other cases, in which the connection of a lake with a river is in doubt, *e.g.* Yamdrok Tso and the Tsangpo.

Although Mānasarowar was the first lake known to geography, it did not give rise to any scientific question, until it was explored by Moorcroft and Hearsey in 1812. In his map of India, dated 1788, Rennell, the Surveyor General, showed correctly that there were two lakes connected by a stream. But Rennell's map represented the two lakes as draining into the river Ganges. Geographers were therefore astonished when Moorcroft discovered that these lakes had no connection with the Ganges. (*Asiatic Researches* Vol. XXII, 1818).

In 1846 Henry Strachey discovered a stream 100 feet wide 3 feet deep connecting Lake Mānasarowar with the more western lake Rakas Tal, and though he discovered no second stream connecting Rakas Tal with the river Sutlej, he came to the conclusion that there was an underground connection between them and he thought it possible that in times of flood the level of the lake might rise and overflow into the river. Henry Strachey was the first to measure the salinity of Tibetan lakes and to make use of it as a test of effluence. If the water

of a lake was salt, he concluded that the lake could have no outlet; if the water were fresh, he assumed that the lake must be connected with a river.

In 1904 Colonel Ryder, afterwards Surveyor General, made a survey of the Mānasarowar region, and fixed the positions of the lakes amid their surrounding mountains. This map was an important contribution; it showed a stream of water running from Mānasarowar into Rakas Tal, but it gave a broken line to the connection between Rakas Tal and the Sutlej. Ryder wrote, "We went "down the old channel from the Rakas Tal to the Sutlej and it was 6 miles before "we saw any sign of water flowing. There may be an underground flow but "not above ground. Rakas Tal was completely frozen; Mānasarowar was only "frozen for a width of 200 yards round the edge: this I thought was due to hot "springs in the lake: I saw such a spring in the channel between the two lakes". On his map Colonel Ryder showed the Rakas Tal as connected with the Sutlej by a dotted line, in order to indicate that the connection had not been visible.

In 1907 the Mānasarowar lakes were measured and sounded by Sven Hedin. He fully realised the great advantages of Ryder's map. But Ryder had made his survey amid the snow and ice of winter when the streams were frozen, whilst Sven Hedin was able to carry out his investigations in summer. He had moreover an advantage over Moorcroft and Strachey, in that he was a Tibetan linguist and on friendly terms with the Tibetans. Moorcroft and Hearsey had been imprisoned by the Tibetans, and Strachey had had to guard against a similar fate. Sven Hedin was thoroughly conversant with the Mānasarowar problems before he arrived on the spot; he was aware of the difficulties which had confronted his predecessors, and he had foreseen what lines of research would have to be undertaken. The first two volumes of Sven Hedin's work on "Southern Tibet" give a complete history of Lake Mānasarowar, and a just appreciation of the work of former explorers.

Sven Hedin saw the stream connecting the two lakes, and as he found the water of both lakes to be quite fresh, he felt convinced that they must be connected with the Sutlej, although at the time no such connection above ground was visible. He has attributed the contradictory results obtained by different observers to the phenomenon of periodicity. The fact that the stream connecting the two lakes had been flowing when Strachey and Ryder were there, and had been dry when Moorcroft was there, he attributed to variations in snowfall and rainfall. In periods of drought the stream will be dry, in periods of fall the stream will be flowing. In periods of exceptional snowfall not only will the stream connecting the two lakes be flowing but a surface stream may also be flowing from the western lake into the Sutlej, and the river and the two lakes will all then be connected. Ryder agreed with Sven Hedin's conclusion that "so long as the lakes remain fresh they must be reckoned to the Sutlej".

The following paragraphs are quoted verbatim from the 1907 edition of this Sketch of Himālayan Geography, (Part III, 1907, page 163).

N

"If the water of the Mānasarowar lakes overflows occasionally into the Sutlej, "they must be regarded as belonging to the basin of the latter. We define a "basin as the whole tract of country drained by a river and its tributaries: by "the word "drained" we do not imply any perpetual flow, but refer only to "times of rain and flood. All the small tributaries of the Himālayan rivers "are dry at certain times of the year, but a dry tributary remains a branch of the "drainage. If the water from Rakas Tal flows into the Sutlej once a century, "and then only for such a short period as to be observed by no one, we shall still "be justified in including the lakes in the catchment area of the river."

Subterranean drainage.—"Henry Strachey was probably right in thinking "that the water of the lakes filtered through the porous soil: examples of such "filtration are common in the alluvial valleys of the Himālaya. Rivers disappear "and subsequently re-appear at the surface. In the underground observatory of "the Trigonometrical Survey at Dehra Dūn water accumulates in the subterra-"nean drains after heavy falls of rain in the neighbouring hills, even when no "rain has fallen locally; the intervening river bed remains dry, and the water "flows along an underground course. These underground systems of drainage "seem to follow closely the beds of surface streams. The latter hold water only "when the volume of flood is too large to sink into the ground, but when the "surface is dry, there is often a flow at a lower level."

The lake of Gunchu Tso.

To the west of Mānasarowar is the lake of Rakas Tal, separated from it by a strip of land 3 to 6 miles wide. Thirty miles east of lake Mānasarowar and at an altitude of 16,000 feet there is a third lake Gunchu Tso, which is 15 miles long. In the 1907 edition of this book in Chart XXXI, the authors decided to include Gunchu Tso in the drainage system of the Sutlej. But Sven Hedin has since tested the water of Gunchu Tso and has found it "quite salt". (*Southern Tibet*, Vol. II, 187). The water of Rakas Tal and Mānasarowar he found "quite fresh". He has thus been led to regard Gunchu Tso as a closed lake basin without outlet, even in times of flood. His conclusion has been accepted in this book, and Chart XXXI showing the basin of the Sutlej has been corrected accordingly. Sven Hedin has quoted Henry Strachey as saying that Tibetan lakes which have an effluence have invariably fresh water, and those without it are invariably salt. In Chapter 30 of this book which was written by Sir Henry Hayden the author has pointed out that there are instances of lakes, which had been reported salt by earlier explorers, being subsequently found to be fresh.

The source of the Sutlej.—There is now a general consensus of opinion in support of Sven Hedin's conclusions, that the Sutlej is flowing from lake Rakas Tal, and that the water of Rakas Tal comes from Mānasarowar. Mānasarowar

itself is a lake valley fed from the north, east and south. Out of all its feeders the Tibetans have selected one, which they have called the source of the Sutlej.

The Tage Tsangpo is the largest and longest of all the mountain streams that flow into lake Mānasarowar. High up on the glacier-fed Tage Tsangpo Sven Hedin found a spring which was regarded as the sacred Langchen-Kamba, and he agreed with the Tibetans that this spring which was the source of the Ganglung Chu and which emanated from the Ganglung glacier, was the principal source of the great river Sutlej (*Southern Tibet*, Vol. II, 142).

The glaciers of the Sutlej.—Numerous glaciers large and small drain into the river Sutlej at various points of its course. East of Mānasarowar and feeding its principal source are the glaciers of the Ganglung Gangri; the southern glaciers of Kailās flow into the Sutlej through the lake of Rakas Tal; the northern glaciers of peak Kāmet are also contributors to its stream. The peak of Riwo Phargyul stands in the Sutlej basin and its glaciers all flow into the Sutlej. There are also many Himālayan glaciers draining into its tributary the Baspa, and many more from the direction of the Bāra Lācha pass and from the watersheds of the Chenāb and Beās.

The course of the Sutlej in Tibet.—From Rakas Tal to Shipki, the Sutlej takes a north-westerly direction through the Tibetan province of Nari Khorsam. The best known portion of Nari Khorsam is the plateau situated between the Zāskār and Ladākh ranges. This plateau is 15,000 feet in height. It has been formed by successive deposits of boulders, gravel, clay and mud in the trough between the two ranges; the deposits lie in parallel and nearly horizontal beds. Nari Khorsam furnishes in fact another example of the common Himālayan type of rock valley filled with recent alluvium.

In one part of Nari Khorsam the water-parting between the Sutlej and Karnāli traverses the level plain of alluvium, and a man can walk from one river to the other without crossing a hill of any sort.

In its course through Nari Khorsam the Sutlej has gradually cut into the unconsolidated deposits and has created an extraordinary canyon—a canyon that bears comparison even with the famous American canyon of Colorado. The Jhelum has created no canyon in Kashmīr because the rainfall over the basin is sufficient there to lower gradually the whole alluvial area; but Nari Khorsam is an arid region, and whilst the Sutlej has been able to excavate a channel 3,000 feet deep through the plateau by means of water received from the glaciers of Kailās, no rain has fallen locally to erode its perpendicular cliffs.

The Sutlej is joined by several tributaries in Nari Khorsam, the beds of which lie 1,000 feet or more below the surface of the plain: their overhanging cliffs like those of the Sutlej have been spared from destruction by rain, and flat portions of the plateau now remain standing between profound gorges.

The passage of the Sutlej through the Zāskār range is near Shipki and within 4½ miles of the summit of Riwo Phargyul, the highest peak on this part of the

range: the proximity of the gorge to the peak is a striking phenomenon. The height of Riwo Phargyul is 22,210 feet, that of the bed of the gorge 10,000 feet, a difference of 12,210 feet. Ten miles below Shipki the right bank of the Sutlej is a perpendicular wall of rock 6,000 or 7,000 feet in height (*Narrative of a journey from Cawnpore to the Boorendo pass made in 1821*, by Lloyd and Gerard, 1840.)

The Spiti river.—The principal tributary of the Sutlej is the Spiti river, which drains a large area behind the great Himālayan range. Its bed lies deep below the alluvial terraces, and its water is consequently rarely available for cultivation. The peak of Shilla, height 23,050 feet, shown on Chart XXXI, is the highest peak at which survey *khalāsis* have erected a survey signal. The *khalāsis* were not Alpine mountaineers and were not equipped as such. Their climb in 1865 attracted no public notice, but is held in honour by the Survey. The name Shilla is the Spiti corruption for the Sanskrit Sila meaning mountain. The stream that rises in the ice of Shilla is known as the Shilla river.

After its junction with the Spiti the Sutlej becomes a furious torrent dashing over a rocky bed, and forms one continuous rapid from its source to the plains. There are, however, signs of the former existence of a series of lakes along its course: terraces composed of stratified deposits are to be seen in many places, and these are evidences that the Sutlej once meandered slowly through Himālayan lakes, as the Jhelum does now through the Wular lake. Many of the feeders of the Sutlej in the hills show signs of having run at higher levels within recent times.

Passage of the Himālaya by the Sutlej.—The Sutlej crosses the great Himālaya at a point where the range bifurcates, and it is difficult to trace a connection between the ranges on either side of it. At Rāmpur it crosses the Dhaula Dhār range through a narrow gorge of solid rock. The passage of the Sutlej across the great Himālaya and the Dhaula Dhār ranges is illustrated in figure 4 of Chart XVI (see also Chart XVIII). Figures 1 and 2 of Chart XIX show the Sutlej escaping through successive Siwālik ranges. It is interesting to observe on Chart XIX how effectually these small ranges stopped and deflected the Sutlej below Bilāspur.

In its course over the plains the Sutlej is supposed to have flowed at one time through the Patiāla and Bikāner states and to have joined the Indus in southern Sind: it now bends to the west on leaving the mountains, and joins the Beās. It is believed to have changed its old and straighter course to the sea for its present and less direct one about the end of the tenth century: the advancing sands of the Rājputāna desert have been supposed to be the cause of the change.

The fall of the Sutlej from its source to the plains of India is very uniform, and averages on every section of its length about 30 or 35 feet per mile: the

height of its bed is 15,000 feet near Rakas Tal, 10,000 feet near Shipki, 3,000 feet at Rāmpur, 1,000 feet at Bilāspur.

The Beās.

The Beās or Beyah (Sanskrit Vipāsa, the Arji-kiya of the Vedas, and the Hyphasis of the Greeks) rises in the Pīr Panjāl range at the Rohtang pass near the source of the Rāvi (Chart XXXII): its several affluents combine to pierce the Dhaula Dhār range at Larji, (Chart XVIII). In the 75 miles from its source to Larji, its fall averages 125 feet a mile but after Larji the gradient rapidly decreases, and in the valleys of the outer Himālaya is hardly more than 10 feet a mile.

The upper basin of the Beās encloses the district of Kulu; and in its course through the hills it traverses Mandi and Kāngra.

Six miles from its source the Beās enters the gorge of Koti. "Here the "river plunges into a vast chasm, enclosed on either side by precipitous barriers "of rock, 20 feet apart and often almost touching. For some 300 yards the "Beās races through this almost subterranean passage, when it again bounds into "sunlight, its exit on the further side being most strikingly beautiful." (*Selections from the records of the Government of the Punjab, No. 10, Himālayan districts,* by Captain Harcourt).

South of Larji the Beās passes through another precipitous defile intersecting the Dhaula Dhār range; below the defile its valley widens out. Sir Alexander Cunningham estimated the minimum discharge of the Beās at not less than 3,000 cubic feet per second.

There are several glaciers at the sources of the Beās and of its tributary the Pārbati in the snow mountains of Sirtkand Dhar, where the Pīr Panjāl range breaks off from the Great Himālaya.

The Rāvi.

The Rāvi (Sanskrit Irāvati, the Parushni of the Vedas, and the Hydraotes of the Greeks), illustrated in Chart XXXII, is the smallest of the five rivers of the Punjab, but it is well-known in India as the river of Lahore: it has its sources in a remarkable mountain knot formed by a conjunction of lesser Himālayan ranges (Chart XVIII). The Nāg Tibba range appears here to have been forced from the south-west against the Dhaula Dhār range, and the latter has combined with the Pīr Panjāl range to form the rock-basin of Bangahal. The Rāvi rises in the basin of Bangahal, and drains the southern slopes of the Pīr Panjāl and the northern slopes of the Dhaula Dhār. The basin of Bangahal is sixty miles in circumference. Numerous tributaries of the Rāvi flow down it

inner walls, many of them with steep gradients; the Bhadal rises on the north at 16,000 feet, and falls 314 feet a mile for 35 miles; the Nai, which rises in the mountain known as Kāli Devi, has a length of 30 miles, and an average fall of 366 feet a mile.

The height of the bed of the Rāvi at the lowest point (Wulas) of the Bangahal basin is about 5,000 feet. Gathering together all the water that runs off the inner walls of this extraordinary rock cauldron, the Rāvi flows out to the west.

The gorge, by which it escapes from Bangahal, may without exaggeration be described as inaccessible: it appears to have been scooped out of solid rock and its sides are perpendicular.

After leaving Bangahal the Rāvi flows through the valley and state of Chamba in a north-westerly direction parallel to the Dhaula Dhār range (Chart XVIII). West of the Chamba capital it makes a sudden bend at right angles and cuts its way through the Dhaula Dhār to the south-west. The defile that it has carved through the range is a few miles north-west of the station of Dalhousie.

The Rāvi leaves the Himālaya at Basaoli: the length of its course in the mountains is 130 miles, and its total drop 15,000 feet; its fall therefore averages 115 feet a mile.

The Chenāb.

The Chenāb (Sanskrit Asikni, the Acesines of the Greeks) has two chief upper streams, the Chandra and the Bhāga, and the river below their junction is called by their joint name the Chandra Bhāga (Chart XXXIII).

The Chandra and the Bhāga rise on opposite sides of the Bāra Lācha pass (16,047 feet), the Chandra on the south-east, the Bhāga on the north-west. They unite at a place called Tandi, 7,500 feet above sea-level. The course of the Bhāga above Tandi is direct and only 60 miles in length: that of the Chandra is in the form of a loop, and is 115 miles long. The fall of the Bhāga is 150 feet a mile, twice that of the Chandra.

"A mile from its source the Bhāga enters the Suraj-dul, a lake about a "mile and a half in circumference, 16,000 feet above sea-level, and escaping through "this flows for ten or eleven miles to below Zingzingbar, a barren encamping ground." (*Selections from the records of the Government of the Punjab, No. 10, Himālayan districts*, by Captain A. F. P. Harcourt.)

"Leaping from a bed of snow on the south-eastern slopes of the Bāra Lācha, "the Chandra is from its commencement a stream of some size. It passes through "a totally barren land, where there are no signs of life, the solemn mountains "clad in eternal snow lying on its either flank. No villages adorn its banks, no "attempts at cultivation, no signs of human life are to be met with, and nothing "greets the eye but the never-ending and monotonous cliffs, which are lapped "by the fierce stream, as it rushes in wild fury against its banks. Now widen-

"ing out the Chandra passes the remains of the Shigri glacier, which some 80 "years ago spread across the river and dammed it up, causing what is known as "the cataclysm of the Chandra." (*On the Himālayan Valleys, Kulu, Lahaul, and Spiti*, by Captain A. F. P. Harcourt. *Journal, R. G. S.*, Vol. XLI, 1871).

After their junction at Tandi the Chandra and the Bhāga flow as a joint stream in a north-westerly direction for over 100 miles: throughout this length the valley of the river is the structural trough formed by the great Himālayan and the Pīr Panjāl ranges (*vide* figure 4 of Chart XVI and Chart XVIII). Instead of continuing on the same alignment through the valley of Kashmīr, the Chenāb makes a great bend at Kishtwār, and escapes through the Pīr Panjāl by a gorge, which it has carved for itself. In the long trough from Tandi to Kishtwār the fall of the river averages 34 feet a mile.

At Kishtwār the Chenāb is joined by the Maru Wardwan river, that has its sources in the glaciers of the Nun Kun peaks.

The Chenāb passes the diminishing range of Dhaula Dhār near Arnas, and leaves the mountains at Akhnur. Akhnur is 180 miles below Kishtwār, and the average fall of the river between the two places is 26 feet a mile.

From the Bāra Lācha pass to Akhnur the length of the Chenāb is 400 miles and the total fall is 15,500 feet, or 39 feet a mile.

It is worthy of notice that the general course of the Chenāb resembles on a smaller scale that of the Sutlej, and that the course of the Rāvi resembles on a still smaller scale that of the Chenāb. The basins of these three rivers, unlike the symmetrical basins of Nepāl, lie obliquely across the mountain ranges.

The Chenāb drains a long section (180 miles) of the Great Himālayan range, including the Nun Kun peaks of Ser and Mer, and it is fed by numerous Himālayan glaciers. In Chapter 18 references are given to Colonel Montgomerie's lecture, in which he mentioned the glaciers of Nun Kun, and also to the observations made by the Geological Survey of India in 1906.

THE JHELUM (CHART XXXIII).

The Jhelum is the river of Kashmīr. In Sanskrit literature the Jhelum is named the Vitasta: by Arrian, Alexander's historian, it was called the Hydaspes, and by Ptolemy the Biduspes. Muhammadan historians have given it the name Behat, a Kashmīri corruption of Vitasta. At the present day different sections of the river are known to the Kashmīris under different local names, Virnāg, Adpal, Sandran.

An important source of the Jhelum is in the lake of Shesha Nāg at the head of the Lidar tributary: several of its tributary-sources unite in the Wular Lake, where they drop their heavy loads of silt: above the lake their fall has been

steep but when the united river leaves the lake, its fall is slight. At its exit from the lake it follows a south-westerly course as far as Bāramūla, where it rushes down a deep gorge which it has cut through the Pīr Panjāl range.

The basin of the Jhelum is a trough formed between the Great Himālaya range and the Pīr Panjāl range: this trough which constitutes the valley of Kashmīr is of oval shape, its long diameter being parallel to the general direction of the two ranges for 90 miles: the width of the valley from the crest of the Great Himālaya to the crest of the Pīr Panjāl is 75 miles, but the width of its level alluvial flats is not more than 25 miles. On the north-east side the peaks of the Great Himālaya rise above 17,000 feet: on the south-west the loftiest peaks of the Pīr Panjāl exceed 15,000 feet.

The height of the alluvium with which the valley is filled, varies from 5,200 to 6,000 feet. The alluvial deposits filling up the basin of Kashmīr were held by the earlier geologists to have been formed from the waste of the surrounding mountains, and to have been laid down at the bottom of a great lake. It has been stated that these deposits once covered the whole valley to a height of 1,000 feet above its present level, and that the greater portion has been carried away by the Jhelum to the plains of the Punjab. The Wular lake, which now measures 10 miles in length and 5 in breadth, was regarded by Montgomerie as a last relic of the great expanse of water which once covered all Kashmīr. But this idea of a great prehistoric lake has been abandoned by Mr. R. D. Oldham. Mr. Oldham studied the Karewas and the present lakes of the Kashmīr valley in 1903, and came to the conclusions that the Karewas are of fluviatile and not of lucustrine origin, and that there was never at any time a materially larger lake than at the present day (*Records, Geological Survey of India*, Vol. XXXII, p. 152).

"The country of Kashmīr," writes Mr. Frederic Drew, "has justly a reputa-"tion for something distinctive, if not unique, in its character. Its position and "form together are such, that there is no parallel to it in the whole of the Himā-"laya. It is a plain embedded among the mountains, a wide vale enclosed by "mountain ranges, lying at such a height above the sea as on the one hand to be "of a climate entirely different from that of India, being saved from the heat that "parches the plains, and on the other hand to be free from the severity of cold "that visits the more lofty plateaux or wide valleys."

Prior to 1294 A.D. the valley of Kashmīr was governed by Hindu kings: from 1294 to 1586 it was subject to Muhammadan rulers. In 1586 it became a part of the Mughal Empire of Delhi, and the Emperors Akbar, Jahāngīr and Shāh Jahān took a great interest in the country. On one occasion when the Emperor Aurangzeb was in Kashmīr, he was visited by the King of Little Tibet

In 1756 Kashmīr was conquered by the Amīr of Afghānistān, Ahmad Shāh Durrāni, and it remained in the hands of the Afghāns till 1819, when it was taken from them by Ranjīt Singh the Sikh monarch of the Punjab. In 1846 after the defeat of Ranjīt Singh by the British it came under the rule of Gulāb Singh the Mahārāja of Jammu.

Passage across the Pīr Panjāl.—The Jhelum enters the Pīr Panjāl range near Bāramūla (5,040 feet) in a direction approximately perpendicular to the strike of the mountains and continues on a straight course for 20 miles to Uri.

The defile below Bāramūla, called by the Kashmīris Basmagul, is 7,000 feet in depth, and has almost perpendicular sides. In places it is but 70 feet across, and its bottom is wholly occupied by the river. (*On the Trigonometrical Survey and physical configuration of the valley of Kashmīr*, by W. H. Purdon. *Journal, R. G. S.*, 1861).

At Uri the river changes its course and follows the direction of the range to Muzaffarābād (2,470 feet). From Bāramūla to Muzaffarābād the distance is 80 miles and the fall 2,600 feet or 33 feet a mile.

At Muzaffarābād the Jhelum joins the Kishanganga and bending to the south follows the course of its affluent. The strike of the rocks changes at the very point where the Jhelum alters its direction and may be the cause of the latter's bend (*Memoirs, Geological Survey of India*, Vol. XXII, 1883, *The Geology of the Kashmīr and Chamba territories and the British District of Khagan*, by R. Lydekker). From Muzaffarābād to the plains the fall of the Jhelum is 21 feet a mile.

The Kishanganga.—The Kishanganga rises in the mountains west of Drās and south of the Deosai plateau. It flows through the districts of Tilail, Gurais and Shardi, and skirts the northern rim of the Kashmīr basin. After following the strike of the ranges it makes a knee-bend at Shardi, similar and parallel to the knee-bends of the Indus at Bunji, of the Jhelum at Wular, of the Chenāb as Kishtwār and of the Rāvi in Chamba.

Colonel Montgomerie, who superintended the survey of Kashmīr from 1854 to 1863, described the valley of the Kishanganga as being throughout very precipitous, and for the greater part little better than a chasm in the mountains. Its basin is peculiarly narrow and elongated, being in places only 17 miles wide from water-parting to water-parting.

The Zoji pass.—The Zoji pass over the Great Himālaya range forms a notch in the rim of the Jhelum's basin: this pass is 500 yards broad and 2 miles long, and its surface is so flat that a pedestrian cannot tell where the actual water-parting is. The ascent from Kashmīr to the top of the Zoji is steep, the descent

on the northern side is gentle. The height of the pass is 11,300 feet; on each of its flanks the crest of the range rises to 13,000 feet, and then by slow degrees to peaks of 19,000 feet. The Zoji was probably cut by an extinct river or glacier during the growth of the Great Himālaya (*Records, Geological Survey of India,* Vol. XXXI, 1904. *Note on the glaciation and history of the Sind Valley, Kashmīr,* by R. D. Oldham).

Glaciers.—Compared with Kumaun the height of the Great Himālayan range is abnormally low throughout the basin of the Jhelum, and the number of glaciers that feed the Jhelum is small compared with those of the Chenāb, and quite insignificant compared with those of the Indus. The Great Himālaya rises to a height of 26,620 feet at its north-west termination in the peak of Nanga Parbat, but Nanga Parbat is in the basin of the Indus and is not on the Jhelum-Indus watershed. Many glaciers descend from the heights of Nanga Parbat but they almost all flow into the Indus. It is only from the peaks on the extreme south of the Nanga Parbat mass that glaciers descend into the basin of the Jhelum; and even these glaciers are few in number and small in size.

CHAPTER 25.

THE INDUS.

The name Indus had its origin in the Sanskrit word Sindhu meaning the ocean. When the Aryan people about 3,000 B.C. migrated into India, from their riverless homes in the Persian uplands, it is little wonder that they compared the Indus with the ocean, for in the north-western Punjab in times of flood the Indus may be 30 miles wide. Many centuries after the Aryan invasion, Darius the Great conquered the Punjab (500 B.C.), and in the inscription upon his rock tomb in Persia the Punjab was called the land of the seven Sindhus, the "Hepta Hendu", and from this corruption of the Sanskrit word "Sindhu", etymologists have derived the modern names Hindu and Indus.

At a later date (300 B.C.) the Greek envoy Megasthenes who was then residing on the Ganges wrote, "The Indus is the biggest of all rivers except the Nile". Megasthenes had travelled to India from Egypt and he had therefore seen the Euphrates and the Tigris, but he knew nothing of the rivers of China. Modern geographers cannot now claim for the Indus such a relative magnitude as their Greek predecessor did, but they have learnt from their surveys many new facts which were unknown to him, and which give to the Indus a high place amongst the principal rivers of the world. No other river of the world is fed by such a wonderful galaxy of great glaciers; no other river collects the drainage of such a number of famous mountain peaks,—peak K^2 and Nanga Parbat, Aling Kangri and Tirich Mīr, Gasherbrum and Sikaram, Rakaposhi and the Takht-i-Sulaimān. Though therefore we cannot now accept the description given by Megasthenes, we fully realise as he did that the Indus is a mighty river.

As late as 1788 the Surveyor General at Calcutta was under the impression that the Indus was flowing to India from Kāshgar, and it was not till 1812 when Moorcroft began his explorations of south-western Tibet that some of the sources of the Indus were found to be situated at no great distances from the sacred Kailās-Mānasarowar region. The discovery that the long river traversing Ladākh was an upper arm of the Indus did not however preclude the possibility of other sources existing in the direction of Kāshgar. But the surveys of Vigne, Henry Strachey, Cunningham and Thomson (1835-1853) proved that the Ladākh arm was a more distant and more clearly defined source than any of the Baltistān or Gilgit or Hunza tributaries.

In the explorations of the Indus all branches of geography have suffered losses: Moorcroft the first explorer died north of the Hindu Kush. In 1871 Captain Basevi of the Survey of India, who was the first geodesist to measure the force of gravity in Tibet, died of pneumonia at More in Ladākh: (his grave is at Srīnagar). In 1874 Dr. F. Stoliczka of the Geological Survey of India

who was the first geologist to survey the Karakorum died of exposure; (his grave is at Leh). In 1912 Lieutenant Bell, R. E. the triangulator, who was extending a series of triangulation from the Indus to the Russian stations on the Pāmirs, died of appendicitis near the Pāmir border.

A twofold system of drainage.—East of longitude 75° the Indus has a long mountain basin trending with the Himālaya and Karakorum ranges from south-east to north-west; west of longitude 75° it has a wide basin trending with the Hindu Kush range from north-east to south-west. In Ladākh the Shyok tributary flows parallel to the Indus for 150 miles in a north-westerly direction, in Swāt and Chitrāl, the Swāt and Kunar tributaries flow parallel to the Indus for 150 and 200 miles in a south-westerly direction.

The complexities of the drainage are increased by ethnological and linguistic difficulties. No other river in the world gives its water to such a diversity of human races, Aryan, Mongolian, Semitic, Dards and Hazāras, Chitrālis and Kāfirs, Swātis, Bunerwāls, Kohistānis. On the banks of the Indus there are languages spoken, which are not in use anywhere else in Asia: a surveyor has not only to delineate the rivers and hills, he has to represent the topography as it is known to the peoples; he has to discover the thousands of geographical names in use, and such discoveries cannot be made without knowledge and understanding.

In the basin of the Indus the mountain ranges of the Himālaya and of Tibet which have followed more or less continuous alignments from China to Kashmīr undergo sudden changes; the Great Himālaya ends at Nanga Parbat and the Karakorum range changes direction into the Hindu Kush: Nanga Parbat is the orographical focus, the Indus circles round it, its tributaries follow suit, and the Karakorum-Hindu Kush range changes its north-westerly direction to its new south-westerly direction.

The source of the Indus.—Since 1907 all doubts concerning the source of the Indus have been set at rest by the explorations of Sven Hedin. We have already shown in this book, how Sven Hedin explored the sources of the Brahmaputra and the Sutlej. Colonel Ryder has written, "Everything Sven Hedin did, he did with his own hands". This tribute from the experienced English explorer brings home to us the scientific loneliness, from which Sven Hedin must have suffered during his long years in Tibet. He was unaccompanied by any European or Indian surveyor. That he must have been handicapped in this respect becomes evident when we read the expressions of gratitude recorded by explorers like Stein and Deasy and Rawling and Visser for the unfailing help they received from their Indian companions. What Sven Hedin did, he did, as Ryder said, with his own hands: every observation he has recorded he made himself, and all the passes and glaciers which he has discovered he reached himself by mountain climbing.

In Southern Tibet the Indus is formed by the junction of two mountain streams (see Chart XXXIV), the northern stream is the Singi Kampa which follows a semi-circular course, the southern is the Gartang Chu which takes a straight course from Gartok. Sven Hedin followed the Gartang Chu from its source to its junction with the Singi Kampa (*Southern Tibet,* Vol. III, Chapter XIII): of the mountains on either side he writes "on the south-west the Ladākh range, "dark, steep and mighty. On the north-east Trans-Himālaya more flat, lower, "reddish."

When he reached the mouth of the valley through which the Singi Kampa emerges, "after having broken through the Trans-Himālaya", he could see that the Singi Kampa was larger than the Gartang Chu, but in order to solve the question definitely he measured the volumes of the two streams just below their junction. The velocity of the Singi Kampa was twice as great as that of the Gartang Chu. The volume of the Singi Kampa was 9·78 cubic metres per second, that of the Gartang Chu 6·67; the ratio of the two volumes was 3 to 2: the Singi Kampa was clearly the larger. The comparison was made in November, and Sven Hedin has given the following caution: "The Gartang Chu may be "the larger river in the rainy season. The Ladākh range is more exposed to "the monsoon than the Trans-Himālaya. The spring floods will thus be greater "in the Gartang. But the Singi Kampa is the more powerful of the two rivers "and presses the Gartang against the very base of the Ladākh range (*Southern "Tibet,* II, 212). At their confluence the Gartang Chu streams along slowly "and quietly, but the Singi Kampa rushes furiously out of its gate in the Trans-"Himālaya" (*Trans-Himālaya,* Vol. III). Having decided that the Singi Kampa must be regarded as issuing from the true source of the Indus, Sven Hedin followed this main branch of the river to its origins in the Trans-Himālaya. The first branch junction that he reached was that of the Langdep Chu: he found that there was a greater volume of water in the Langdep Chu than in the Singi itself, and he was inclined to regard it as the source of the Indus, but as it was held by the local Tibetans to be a tributary only, he accepted their view, and he persevered in climbing the rocky bed of the Singi. The volume of water in the next tributary the Munjam flowing into the Singi Kampa was very small (one-third of a cubic metre), and Sven Hedin continued his climb to the particular source, which the Tibetans called the source of the Singi Kampa. This source is known as the Singi-Kabab, "the Lion's mouth", and is 16,941 feet high. "At this point the Singi Kampa is born. But the infant river which "is a mere brook is shorter than either the Lungdep or Munjam". "The "problem cannot be settled," Sven Hedin writes, "in any more satisfactory "way than to accept the Tibetan view and to regard the Singi-Kabab as the "source of the Indus in spite of its being the shortest and one of the smallest of "the several source branches". A river like the Indus must have innumerable ultimate sources, and no scientific rules can be laid down as to how the principal

source is to be selected. In a school or lecture it is useful to be able to point to a particular source and to say, "That is the source of the Indus".

There can be no doubt now that the principal source of the Indus is situated in Southern Tibet and not in the Karakorum or Hindu Kush, and of its two final branches in Southern Tibet the Singi Kampa has been selected as more suitable than the Gartang Chu. The principal source must therefore be located in the Trans-Himālaya, and Sven Hedin acted wisely in leaving the choice of the particular Trans-Himālayan source to the Tibetans of the country. They have chosen the Singi-Kabab, height 16,941 feet, and geographers may accept with confidence the decision of the great Swedish explorer and may endorse his agreement with the local inhabitants (*Southern Tibet*, Vol. II, 213).

Sven Hedin's explorations have placed the source of the Indus in latitude 31° 15′ and longitude 81° 40′. By an unfortunate misprint the source of the Indus has not been correctly shown in Hedin's own Chart LXXXIX of volume VII of his *Southern Tibet*, and this misprint, which is obviously due to an oversight, has been continued in Professor De Margerie's helpful book. Chart LXXXIX of *Southern Tibet* gives in a small space a valuable generalization of the principal features of Tibet.

Intersections of the Ladākh range by the Indus.—For its first 180 miles the Indus (Chart XXXIV) flows in a north-westerly direction along the *inner* flank of the Ladākh range. It then forsakes the trough, and bending at right angles cuts through the Ladākh range near Thangra. Having pierced the range it resumes its north-westerly direction, and this it maintains along the *outer* flank of the Ladākh range for over 300 miles. Near Skārdu (8,900 feet) it cuts again through the Ladākh range, and having crossed back to its original trough, pursues the same north-westerly direction along the *inner* flank. Beyond Skārdu the original alignment of the Ladākh range has been difficult to trace with confidence owing to its erosion by drainage. The range appears to bifurcate, its highest branch becoming the Haramosh ridge, and a minor branch crossing the Indus at Bunji and becoming the southern watershed of the Gilgit river.

The sudden termination of the Great Himālayan range.—The Great Himālayan range trends on a curvilinear alignment for 1,500 miles from Burma to Kashmīr and it then ends suddenly at the peak of Nanga Parbat, (26,620 feet). This abrupt termination has for years given rise to surprise and incredulity. When a long range of mountains stretches across the face of the earth, the reasonable supposition is that towards its terminations it will gradually decline in height and that it will eventually disappear below the surface of the crust. It is possible that the Great Himālaya range does terminate in this manner at its eastern end in China, but in Kohistān south of Hunza there is no gradual disappearance.

True it is, that north of Kashmīr the great range declines in height and becomes lower than in any other section of its trend; true it is, that throughout

its last 120 miles the range that has given so many famous peaks to Nepāl and Kumaun gives no high peaks to Kashmīr. If such a decline had continued, we should have no geographical problem. But instead of decreasing and dying, the range revives and rises above 26,000 feet in the peak of Nanga Parbat, which is the highest point of the Himālaya outside Nepāl. Nanga Parbat is higher than Nanda Devi, and is only 175 feet lower than Dhaulāgiri. The peak of Nanga Parbat has enhanced the geographical interest of the Himālaya mountains and of Kashmīr.

Nanga Parbat by itself would not have led to any special problem: it would merely have gained its place among the high peaks of the world. What has appeared so surprising has been that the Great Himālaya after its long course from Burma should have risen suddenly above 26,000 feet, and should then have disappeared from the face of the earth. Naturally surveyors have explored the Kohistān to try to discover what has happened.

When the Brahmaputra after its long course through Tibet escapes eventually into Assam, it passes through narrow Himālayan gorges, which it has cut across the Himālayan barrier. But the Indus found a way of escape from the plateau that was comparatively open and easy. After its high-level course of 400 miles through Tibet, it found the barrier removed west of Nanga Parbat and an open way,—open compared with the passage of the Brahmaputra,—along which it has been able to flow down to the plains and sea. The Indus did not have to pierce the great range; it had only to turn it.

From 1856 to 1879 trigonometrical surveyors endeavoured to trace the Great Himālayan range beyond the Indus, but they failed to discover any line of heights or any linear arrangement. In the 1907 edition of this book the authors summed up the geographical position in the following words,—"the problem will not be solved without a geological survey". (Part II, p. 80).

The Geological solution.—In 1932 the Geological Survey of India published an important paper upon the problem of the North-West Himālaya, and in this paper Mr. D. N. Wadia has after 9 years of field-work and study put forward his solution. The solution is scientific and cannot be explained without the use of technical expressions (*The Syntaxis of the North-West Himālaya; Records, Geological Survey of India*, LXV, Part 2).

Mr. Wadia has discovered that there is a triangular promontory of ancient rocks, which approximate in character to those of the Arāvalli hills in Rājputāna, and which are now buried under more recent deposits, and that this promontory is pointing and projecting like a foreland into the Hazāra region south of the Kohistān and east of Buner. The Himālaya mountains have been compressed against this foreland and thrown back by its resistance.

When a Himālayan problem has been found by geographers to be insoluble, they have to pass it on to their geological colleagues. The geological solution will possibly meet with criticism from geologists in Europe. But when we consider

how trigonometrical surveyors tramped in former years over the Trans-Indus Kohistān in search of the missing range, and how unsuccessful their search was, it certainly would not be becoming on their part to join in criticising the solution, which their geological colleague has courageously put forward. As a general rule geological theories and solutions are regarded by Himālayan explorers as too technical and abstruse for their comprehension; but in the present case the sudden disappearance of the Himālayan range has aroused so much interest that the geologists will be eventually pressed to explain their solution in simple language. Surveyors will be interested now in seeking for evidence in favour of Wadia's geological idea.

If the configuration of surface features can be accepted by geologists as evidence, the shape of the Nanga Parbat massif certainly supports the idea that there has been some force intervening from the side of India and bending the Himālayan alignment back towards Baltistān. North of Kashmīr the Himālayan range follows a north-westerly alignment until it reaches the Indus, but shortly before its final termination the Nanga Parbat buttress, 40 miles long, branches off from the range at right angles to it. This Nanga Parbat buttress is no ordinary feature. The highest peaks of the Himālaya, Mount Everest, Kānchenjunga, Makālu, Dhaulāgiri rise from the main range: Nanga Parbat which is almost as high as Dhaulāgiri rises from a long perpendicular buttress. There is no other case of a supreme peak standing 20 miles to one side of the main crest-line, and there is no other case of a buttress that for a length of 40 miles rises continuously above the snowline when the main range itself does not reach the snowline.

Both the peak and the buttress are abnormalities; immediately to their north, just beyond the Indus, is another abnormality in the Haramosh ridge which carries the peak of Rakaposhi. For years this high ridge has been an enigma; its place in geography has been considered in Chapter 12, Part II of this book. The juxtaposition of these abnormal features will lead geographers to receive with sympathy Wadia's theory that a promontory of ancient rock has been protruding from India and has interfered with the prolongation of the Himālayan range.

The glaciers of the Indus.—The glaciers of the Indus have to be divided into two great groups, the Karakorum and the Hindu Kush, and these groups have to be considered separately. Nothing definite was known of the Hindu Kush glaciers, until they were surveyed during the recent survey of Chitrāl under Colonel Lewis.

The glaciers of the Karakorum are larger than those of any other mountains outside the polar regions. It is difficult to see how the presence of these glaciers can be explained by existing meteorological conditions. The conclusion is almost unavoidable, that they must be relics of a former glacial epoch and that in our time they are slowly melting away. Even in the still drier climate of the Kunlun

small glaciers and snow-caps still exist, and their presence cannot be attributed to annual snowfall. The gradual dessication of the Takla Makān rivers is probably a sign that their glacial sources have been contracting. A comparison of the maps of the Karakorum with those of the Himālaya shows that the Balti section of the Karakorum have probably been elevated more recently than the Himālaya: the fact that the Balti-Karakorum glaciers are still lying in longitudinal troughs is evidence that these mountains are probably young. The persistent parallelism of the crest-lines and glaciers and rivers has no counterpart in the Higher Himālaya, where the glacial drainage has had ample time to carve the crest-zone into transverse valleys. There is a general parallelism of the main Karakorum crest-line, Kunjut-Gasherbrum, and of the Masherbrum ridge and Ladākh range, with the Batura, Hispar, Biafo, Baltoro, Chogo Lungma glaciers and with the long Upper Siachen-Teram Shehr-Rimo zone of ice and with the long Shyok, Shigar, Braldu, Saltoro, Chapursan rivers.

There is further evidence to show that the Karakorum mountains of Baltistān are of recent uplift. Their highest peaks occur between Gilgit and Depsang, and nowhere on this section of the range has any tributary of the Indus had time yet to cut back and to capture drainage from the Turkistān basin: but on the two flanks, that is on the Gilgit section and on the Depsang section, feeders of the Indus have been successful in robbing the Turkistān basin of its water. It might be argued that the higher the crest-line the more difficult it is for streams to pierce it. But the higher the crest-line the greater is the fall of the streams and the greater their erosive power. In view of the facts that the Gilgit and Depsang rivers have been able to cut back behind the crest-line, the presence of the peaks of K^2, Gasherbrum and Teram Kangri upon the Balti watershed of the Indus is evidence of their relative youth.

The dimensions and positions of all the great glaciers are now known; it is unlikely that any new glacier will be discovered in the basin of the Indus (or elsewhere in the world outside the polar regions) that will rival in magnitude the Hispar, Batura, or the Baltoro, Biafo, or Siachen-Rimo. The details of the geographical work are by no means completed, but the explorations of the last hundred years have made known the main features. The length of the longest glaciers of the Indus have already been given in Chapter 18 of this book. They are as follows:—

Glacier.	Tributary stream.	Height of snout.	Length in miles.
Siachen	Nubra	12,150	45
Hispar	Hunza	10,500	38
Biafo	Shigar	10,360	37
Baltoro	Draining the slopes of K^2 into the Shigar.	11,580	36
Batura	Hunza	8,030	36

In 1906 six glaciers were surveyed by the Himālayan geologist Sir Henry Hayden; his maps and the marks he left on the rocks are a valuable record of the positions occupied by the snouts in 1906. Hayden's glaciers were the following:—

1. The Hispar, Minapin, and the Yengutsa, all in Nagir.
2. The Hasanābād in Hunza.
3. The Barche and Himarche both of which feed the Bagrot tributary of the Gilgit river.

An account of Hayden's surveys was published in the Records of the Geological Survey of India, July 1907, Vol. XXXV.

An historic account of the Karakorum glaciers was compiled by Major K. Mason and published in the Records of the Geological Survey of India, LXII, 1930. This is a complete and interesting record, and it will be of value in the next century. It shows that the observations hitherto made have given no conclusive evidence as yet of secular change. The glaciers which are recorded in Mason's paper are the following:—

(*a*) Five glaciers draining into the Hunza river, south of the Karakorum range:—Hispar, Yengutsa, Hopar, Minapin, Hasanābād.

(*b*) Fourteen glaciers draining into the Hunza river north of the Karakorum range (*Among the Karakorum Glaciers*, by Mr. and Mrs. Visser):—Sasaini, Pasu, Batura, Ghutaligi Yaz, Lupghar Yaz, Momhil Yaz, Malangutti Yaz, Yarghil, Khurdopin, Virjerab, Parpik, Kuksel, North Maidur, South Maidur.

(*c*) Three glaciers draining into the Shigar river south of Karakorum range in Baltistān:—Biafo, Punmah, Baltoro.

(*d*) Two glaciers draining into the Nubra-Shyok rivers south of the Karakorum in Baltistān:—Siachen, Mamostong.

(*e*) Three glaciers of the Shaksgam river, north of the Karakorum:—Gasherbrum, Ordok, Kyagar.

(*f*) Five glaciers of the Karakorum in Depsang:—Rimo, two branches draining into the Upper Shyok river. Rimo, one branch draining into the Yārkand river. Chong Kumdan, Kulak Kumdan, Aktash, Lungmo-Chhe all four draining into the Upper Shyok.

The Duke of Abruzzi's expedition in 1909 took observations of the rate of movement of the ice in the Baltoro glacier (longitudinal). The velocity of the ice was found to be 5 feet 10 inches in 24 hours.

The principal tributaries of the Indus.—We have so far been treating of the Indus itself, and we have now to refer to its tributaries; of these the following are the most important:—

(1) the Zāskār, (2) the Drās, (3) the Shyok, (4) the Shigar, (5) the Gilgit and (6) the Kābul.

The areas of the catchment basins drained by the six tributaries may be approximately estimated as follows:—

Kābul river 35,000 square miles.
Shyok river 13,000 square miles.
Gilgit river 10,000 square miles.
Zāskār river 10,000 square miles.
Drās river 5,000 square miles.
Shigar river 5,000 square miles.

It helps us to realise the importance of the Indus when we consider that its Kābul tributary alone has a larger drainage basin in the mountains than any of the great Himālayan rivers with the exception of the Brahmaputra.

The Zāskār.—The Zāskār rises between the Indus and the Great Himālaya range; at its commencement it flows towards the range, as though it were going to pierce it, but it sweeps round through two right angles, and turning away from the Great Himālaya, it pierces the Zāskār range, in which it has its source, and joins the Indus below Leh.

From its source to Padam (12,000 feet) the distance is 140 miles, and the fall is 4,000 feet (28 feet per mile). At Padam the Zāskār makes its second bend, and adopts its final direction towards the Indus: from Padam to the Indus the length of the river is 90 miles, and the fall 2,000 feet or 22 feet per mile. According to Henry Strachey the main supply of water in the upper part of the Ladākh Indus is derived from the Zāskār river.

The Drās.—The Drās river drains the plains of Deosai by means of its two tributaries, the Shingo and southern Shigar*: it also drains the mountain slopes north of the Zoji pass. Its tributary the Suru, starts like the Zāskār on a course towards the Great Himālaya, but eventually bends completely round and flows away from the range. The Suru makes an extraordinary loop at the base of the Nun Kun peaks. Dr. Neve writes that the Suru river, having cut a deep and narrow gorge at its bend, has become roofed in by boulders and debris for 300 yards.

The Shyok.—The Shyok is the best known of the Tibetan tributaries of the Indus, because its valley leads to the famous Karakorum pass, which has always been the connecting passage between India and Central Asia.

The Shyok rises behind the crest of the Karakorum range, and after cutting through the higher part of the range it joins the Indus near Kiris. The passage of the Shyok across the Karakorum is indicated in the longitudinal section of Chart XX.

A theory has been put forward that the watershed of the Shyok is not part of the Karakorum range at all but that it belongs to the Aghil range. This

* Not to be confused with the northern Shigar river, which joins the Indus near Skārdu.

question has already been considered in Part II. It must be borne in mind that the "Karakorum range" is not in nature a narrow line, as it is shown on small scale maps, but a flat arch 60 or 80 miles wide. Its shape resembles the flattish arched back of a crocodile covered with small excrescences. Its height though very impressive to the traveller is small compared with its width. Chart XXXIV shows that the watershed of the Indus adheres to the crest-line of high Karakorum peaks from longitude 75° to 77°. On the other hand towards the south-east and towards the north-west the watershed appears to have been forced by the southern rivers to retire northwards behind the crest-line. Thus it is that on Chart XXXIV the watershed assumes the form of a curved bay, projecting from the Karakorum towards Turkistān, both from Depsang (long. 78°) and from Hunza (long. 75°). When we try to account for these bays in the watershed, it is advisable to adopt the simplest explanation that meets their case, and the simplest explanation is that these two bays have been created by drainage*: in the central Karakorum the Shaksgam river is collecting all the drainage from the Turkistān side of the range and carrying it into the Yārkand river: on the two flanks tributaries of the Indus have cut back through the crest-line and have attracted some of the drainage from the Turkistān side of the range into the Indus. There seems no justification for introducing any Aghil range into this problem. The chart of Aghil ranges published by the Geographical Journal was clearly based upon a misconception for it placed the Karakorum pass in a valley between two ranges (*Geographical Journal*, September 1929, and other numbers): the Karakorum pass is on the watershed of the Indus, and it is the highest point of the road between India and Kāshgar (*Proceedings of the Royal Society*, A, Vol. 127, 1930).

It was conjectured in 1907 that an Aghil range might be running parallel to the Karakorum range on the north, but Filippi's and Wood's surveys in 1914 showed this conjecture to be wrong. If there had been any such range, there would have been a long tectonic trough between them, but there is no such trough. On the Turkistān side of the watershed between the peaks of K^2 and Gasherbrum there is the short drainage trough of the Shaksgam, a tributary of the Yārkand river. And on the Indian side of the watershed there are the short drainage troughs of Depsang and Hunza.† There is nothing abnormal in these alternations of drainage: the rocks out of which the mountains are built are of various characters and types, and their differences affect the drainage.

* Lakes may have existed there and in the Karakorum before they had been tapped by the rivers.

† Geographers always endeavour to adhere to the simple terms of ordinary speech. Their endeavour to avoid technical terms leads at times to slight misunderstandings. The word "range" is at times employed in somewhat different ways, and the word "trough" is sometimes used to denote a basin carved out by a glacier and sometimes a much longer basin formed in the crust between two parallel ranges. The word "trough" itself merely means a basin, however formed or shaped, and we have to appreciate the particular kind of trough from the context. A tectonic trough is a long trough formed between two parallel ranges, a drainage trough is the short trough scooped out of rock by ice or water.

The principal tributary of the Shyok is the Nubra which has its source in the Siachen glacier. A further reference is made to the Shyok in Chapter 26.

The source of the Shyok.—The principal sources of the Upper Shyok river are the Rimo glaciers, which flow from the Karakorum heights into the Depsang trough. The Rimo glacier was indicated vaguely by Johnson upon his map in 1866; its first accurate survey was made by the Italian expedition of 1913-14 under Filippi, and its relation to the Siachen glacier was subsequently explored by Dainelli [*The Italian Expedition to the Himālaya, Karakorum and Eastern Turkistān* (1913-14) by Filippo de Filippi]. Filippi showed that this glacier was astride the Central Asian watershed, and that whilst two branches of it were descending the Indian side of the great divide and were flowing into the Shyok, one important branch was flowing down the Turki side of the divide and was feeding the Yārkand river. Filippi found that one branch of the Rimo was 23½ miles long.

The course of the Upper Shyok.—Whilst the bay in the watershed at the source of the Shyok can be regarded as a result of drainage, and by no means an abnormal result, the sudden change of course which the Shyok river undergoes, as it rounds the nose of the Sasir ridge, is so remarkable that it can hardly be attributed to normal drainage development. It is not unusual in the Garhwāl and Nepāl Himālaya, when a river is flowing down from the snowy crest of the Great Himālaya, to see it abruptly stopped by an outer range and its course deflected at right angles. But there are unique features in the deflection of the Upper Shyok. In the Himālaya an outer range will cross the course of a falling river at right angles and will deflect it through a right angle, but the course of the Upper Shyok river is deflected near the town of Shyok, not merely through a right angle, but almost through two: above its knee-bend the course of the Shyok is *from* the NNW.: below its knee-bend its course is to the NW. Another peculiarity that separates the case of the Shyok from those of the Himālayan rivers is that, whereas the latter though stopped and deflected for a time, do always after a short run find a passage through the blocking range, the Shyok finds no near passage of escape. At its knee-bend it is blocked by the Ladākh range, and for nearly 200 miles it is confined to its new course by this range, which it is unable to penetrate until it joins the Shigar river at Skārdu: the Ladākh range here is 19,000 to 20,000 feet high.

It is a curious fact that the Nubra the great tributary of the Shyok follows a course parallel to the Upper Shyok, and flows into the lower Shyok in a direction opposed to the latter (Chart XXXIV). When tributary streams are opposed to the flow of their main river, they give rise to the idea that the latter must at no very distant date have flowed in the opposite direction to its present course, and the conjecture is permissible that the whole Shyok river flowed at one time into the Pangong lake and joined with the upper branch of the Indus

in piercing the Ladākh range at Thangra (Hanle) between Nichung and Chumik (Chart XXXIV).

Throughout the Himālaya when a river turns and pierces the range that has been confining it, it is generally found that before it cuts its gorge of escape it is reinforced by another river flowing from an opposite direction. When therefore the Indus abandons the northern flank of the Ladākh range at Thangra (Hanle) and cuts a gorge across it, it is reasonable to look expectantly for some reinforcing stream, and finding none our eyes are attracted on the map to the two branches of the Shyok river and to the Nubra river all pursuing courses, that now seem irregular and contradictory, but that do still aim for the Thangra (Hanle) gorge, although they no longer reach it.

The northern Shigar.—The northern Shigar river drains the southern slopes of K² and collects its main waters from the Biafo, Baltoro and Chogo Lungma glaciers.

The Gilgit.—The Gilgit river has two principal branches, the Gilgit and the Hunza: both branches have pierced the Karakorum-Hindu Kush range, and both now drain considerable areas behind it. The Gilgit is the more westerly branch, and has its sources near the Darkot and Baroghil passes of the Hindu Kush.

The ranges of the Hindu Kush.—The names Karakorum and Hindu Kush are applied to different portions of the same great mountain range: the actual meeting point of these two names cannot be based upon the authority of the local inhabitants. Neither of these names is a Hunza or Gilgiti name: the name Karakorum was first applied to the range in Baltistān, and as the same high range was found to continue westwards into Hunza, surveyors continued the name along it. The name Hindu Kush has for centuries been applied by Afghāns and Chitrālis to the great range of Afghānistān and Chitrāl, and when surveyors found that this high range was continuing from Afghānistān to Hunza they naturally extended the name along it. The Chahardar pass over the Hindu Kush north of Kābul is 300 miles from the Baroghil pass over the Hindu Kush in northern Chitrāl.

The Karakorum and Hindu Kush ranges meet in Hunza-Gilgit. The peoples of the Karakorum differ in race and language from the peoples of the Hindu Kush. Alexander the Great and the Emperor Bābar crossed the Hindu Kush, and their crossings are famous in history, but their historians knew nothing of the Karakorum. In 1855-65 a scientific school of surveyors mapped the Karakorum from Tibet to Hunza; in 1879-95 a military school mapped the Hindu Kush from Afghānistān to Gilgit. It was only in 1906 that the Trigonometrical Survey became convinced that the Karakorum range, entering Hunza-Gilgit from the eastt was the same high earth-fold as the Hindu Kush range that was entering Gilgit-Hunza from the south-west. The range that runs from Tibet to Afghānistān is therefore one, whilst the names attached to it are two.

The idea of a Northern and a Southern Hindu Kush range was based by the eminent soldier surveyors, Colonels Holdich, Woodthorpe and Wauhope upon the observations which they made during the Afghān war, 1879-80 and during the subsequent boundary commissions. Holdich thought that the highest peaks were standing on a forward alignment in front of the watershed range. Colonel Lewis, who was in charge of the recent survey of Chitrāl, and who had greater opportunities of studying closely the topographical details of the Hindu Kush, is of opinion that the watershed and the highest peaks all belong to one range. In forming this opinion he is taking a broad view of the great range as a whole. Colonel Lewis writes, "The high peaks of Tirich Mīr, Istor-o-Nal, and Sar-Istragh "though not on the watershed are so close to it, and joined to it by such high "ridges that there can be no question about their belonging to the original range."

The two-fold character of the Hindu Kush range was held by Holdich and Wauhope to be realised and understood by the local inhabitants, for the latter have regarded the two passes, the Baroghil (12,460 feet) and the Darkot (15,380 feet), as crossing the Hindu Kush, and in literature these passes have been attributed to the Hindu Kush. But they are on different and parallel ranges, the Baroghil being 11 miles north of the Darkot. Colonel Lewis writes, "The "point is this: so long as the name Hindu Rāj was not in use, it was natural to "consider the two ranges carrying the Baroghil and Darkot passes as part of the "Hindu Kush: but if the name Hindu Rāj is to be introduced, then I think it "should extend through the Darkot pass".

The Hindu Rāj Range.—Colonel Woodthorpe tells us that the name Hindu Rāj was applied by Colonel Tanner to the lofty chain of peaks south of the Shandur pass, separating Chitrāl and Yasin from the Swāt and Panjkora basins.

Colonel Lewis prefers to extend the name north-east-wards to cover the whole range from the Lowarai pass through the Darkot pass, making its junction with the Hindu Kush and the Karakorum ranges at the head of the Yārkhūn river. The Hindu Rāj as thus defined forms the southern and eastern boundary of Chitrāl. It is crossed by the important passes of Lowarai (10,528 feet), Shandur (12,250 feet) and Darkot (15,380 feet) besides others of less renown. It rises to many peaks of over 21,000 feet.

There are other names applied to portions of this range north of the Shandur pass, such as Shandur, Mashabar, and Sakiz Jarab.

Though existing small scale maps shew it as interrupted at the Shandur pass, yet the range is well shewn on the older quarter-inch maps as a formidable physical feature. It is of the greater importance in that it forms the natural fence closing in the south and east of the Chitrāl valley, shutting its people off from the tribes of Yasin and Swāt. Both geographically and geologically this range is worthy of a name as whole.

Woodthorpe, in 1886, defined Chitrāl as including Yasin and the Karambar and Ghizar valleys, which drain into the Gilgit river, and said, "Practically

"speaking, Chitrāl includes everything between the Hindu Kush and the Hindu "Rāj ranges." Under modern conditions Chitrāl has no political connection with Yasin, and with the new definition of the name Hindu Rāj, Chitrāl is still enclosed by these two great ranges.

The origin of the name Hindu Rāj is obscure, and has been referred to in Chapter 4. It seems out of place now amongst the Muhammadans of Chitrāl and Kohistān; but many countries possess geographical names that have originated under conditions that have passed away. Tanner in 1883 writes that the Muhammadan people of Dardistān were all Buddhists seven generations ago. The name may be accepted as a relic of the past.

During work on the Darkot pass a Survey *khalāsi* fell into a glacial crevasse and broke his leg and jaw; the crevasse was so deep that his extrication was difficult. Fortunately Captain Coldstream, Indian Medical Service, was with the Survey detachment, and he was able to raise the *khalāsi* by ropes out of the ice. He remained on the pass for a week until the *khalāsi* was fit to be moved. Captain Coldstream was the son of Colonel W. M. Coldstream, whose long services in charge of the Map Publication Offices in Calcutta have been of so much value to the Survey.

The glaciers of the Hindu Kush.—Very little was known of the glaciers of the Hindu Kush, until the Chitrāl Survey was carried out under Colonel Lewis in 1927-31. In the General Report, Survey of India, 1928-29, the Surveyor General wrote that this survey required careful organisation and considerable enterprise, as officers and surveyors with no experience of high-climbing had to observe from stations well over 18,000 feet. West of Tirich Mīr, Lieutenant Cadell, R.E., observed for triangulation at stations on the watershed, 19,750 feet and 18,230 feet high. North-east of Tirich Mīr, Lieutenants D. M. Burn, R.E. and I. H. R. Wilson, R.E., and Sub-Assistant Superintendent Chirāgh Shāh observed at many stations above 18,000 feet.

Lieut. Burn, who has been recently killed when mountain-climbing in Kashmīr, reached 19,500 feet on Buni Zom, and observed at 19,040 feet on Chapakgark, and at 18,210 feet on Shahbang. Lieut. Wilson observed at 18,750 feet (Shahbang). Sub-Assistant Superintendent Chirāgh Shāh showed himself a courageous mountaineer: he triangulated from Chargab (19,490 feet), from Chapakgark (19,040 feet), and Karambar (18,800 feet). Colonel Lewis writes, "It must "be remembered that it is the temperature and the rainfall that govern the height "of the snowline, and influence the climbing difficulties. In the Hindu Kush "the average snowline is about 17,000 feet: this is a good deal lower than in the "Karakorum. If we omit from consideration the lack of oxygen, a peak of 19,000 "feet would correspond to one of 21,000 feet in a range where the snowline is "19,000 feet."

Near Tirich Mīr the Hindu Kush watershed has been moved northwards on maps 10 miles by the new survey: this error in the old maps has been due to the

assumption that the higher peaks were actually on the watershed here, whereas three large streams, Atrak, Ziwar, and Uzhnu were found by Lewis to have cut back considerable distances: these hinder valleys contain large glacier systems not previously known. The upper and lower Tirich glaciers, "if counted as one glacier which they must have been until recently" (Lewis), are 18 miles long: the Atrak glacier is 18 miles long. The longest glacier surveyed was the Chiantar, forming the source of the Yārkhūn (Chitrāl) river: the Chiantar is 21 miles long. The Kotgaz is 12 miles long.

The Karambar glacier is 16 miles long, and not 6, as hitherto believed: it has its sources on the peak 23,434 feet, and joins the main valley at its easternmost bend.

There are 3 transverse glaciers which dam their main valley, the Karambar is one, and the other two are known locally as Chhatiboi (meaning "there will be a lake").

Colonel Lewis estimates the length of glaciers that have been recently surveyed, (omitting all glaciers less than 4 miles in length) as,

in the Hindu Kush	370 miles
in the Hindu Rāj	540 miles
in the Karakorum	80 miles
on the Haramosh ridge	50 miles
on Nanga Parbat	60 miles
Total .	1,100 miles

The large glaciers counted above form about one-third of the total number of glaciers surveyed: the remaining two-thirds are the glaciers of 4 miles in length and less.

Floods.—The Indus, like rivers of the Himālaya, is subject to sudden and extraordinary floods: these are due not to excessive rainfall but to the damming of the river by landslips or glaciers.

In December 1840, a side of the hill known as the Hattoo Pīr fell into the defile of the Indus at the base of Nanga Parbat, and formed a dam 1,000 feet high. An immense lake was created behind the dam, the water in which became at one place 900 feet deep; at Bunji the water rose to the level of the fort, 300 feet above the bed of the river; the lake being nearly 40 miles long reached almost to Gilgit town. For six months the waters were held back by the debris of the fallen mountain, till they rose to the level of the top of the dam. The dam then burst, and the lake emptied in one day, the immense volume of water rushing down to Attock. (This account is given on the authority of Colonel Montgomerie. Mr. D. Fraser in his "*Marches of Hindustān*" attributes the cataclysm of the Indus in 1841 to the damming of the river by a glacier).

In 1893 a tributary of the Ganges was dammed at Gohna by the fall across its course of a mountain side. That there was no loss of life, when the dam burst and the lake emptied, was due to the many precautions taken by the Government.

In 1926, 1929 and again in 1932 the Upper Shyok river was dammed by a glacier protruding across it. In 1932 the dam was 400 feet high and a quarter of a mile in thickness. Great apprehensions were then felt for the safety of the villages in the mountains, and even for those in the Punjab and Sind. When the glacial barrier burst, the Indus at Skārdu rose 28 feet in forty minutes. That so little loss of life occurred was due to the elaborate precautions taken by the several governments concerned.

CHAPTER 26.

THE CENTRAL ASIAN WATER-PARTING.

The seven preceding chapters of this book have been devoted to the rivers that flow down from the Tibet highlands into India. In this chapter the rivers will be described which flow down from the Tibet highlands into Turkistān. Of the Indian rivers the Indus is the only one which through its tributaries drains the Central Asian watershed. The closed lake basin of Tibet intervenes between the other Indian rivers and the rivers of Turkistān.

The five rivers that flow northwards from Tibet into the desert of Turkistān are known by the following names (from west to east):—

1. Yārkand river (Tārīm).
2. Karakāsh.
3. Yurungkāsh.
4. Keriya.
5. Cherchen.

Chart XXXV has been drawn to illustrate the primary water-partings. The highest ranges of mountains are shown by dotted lines with heavier dots at intervals to symbolise peaks, and the main water-partings are shown by black continuous lines. In places where the highest range forms the main water-parting, a dotted line and a continuous line have been drawn side by side. The water-parting between India and Tibet has been shown by a double line.

In Chart XXXV the areas marked A and D are drained by the tributaries of the Yārkand (Tārīm) river that rise in the Pāmirs and Tien Shan: the area marked E is drained by the tributaries of the Yārkand river that rise in the Karakorum range.

The areas marked B and C and H belong to the basin of the Indus: and the areas F and J are drained by the Karakāsh, Yurungkāsh, and Keriya rivers. The areas Z, K, and L belong to the Sutlej drainage, Z representing the Mānasarowar basin. The areas M, N, P and R are drained by tributaries of the Ganges, and the area S by tributaries of the Brahmaputra.

This chart XXXV emphasises one significant coincidence. In the Punjab the Great Himālayan range is the Himālayan watershed, but in Kumaun, Nepāl and Assam it is not so. The range ceases to be the watershed just west of the point K on the chart; at the corresponding point H, north of K, the Karakorum also ceases to be the watershed. At K the Himālayan watershed moves from the main crest to a lesser range in rear, and at H the Karakorum gives place to the Tibet lake basin.

The Yārkand River.

Judged by volume of water the Yārkand river is the only one of the five rivers of northern Tibet that can be classed with the Himālayan rivers of India.

The Yārkand river has its sources in the glaciers of the Karakorum range. North of the Karakorum the Yārkand river has two main branches, the Raskam and Shaksgam.

In 1913-14 the Italian expedition under Filippi made the surprising discovery that the Rimo glacier was astride the Central Asian watershed:—that on the Indian side of the watershed this glacier was feeding the Shyok river, and on the Turki side it was feeding the Raskam. (Colonel Wood's *Report on explorations in the Karakorum and Yārkand Valley*, 1922). The watershed ridge of the Depsang-Karakorum, which is the ridge crossed by the Karakorum pass, is the Shyok-Raskam divide: it is the Central Asian watershed between H and F on Chart XXXV.

The Shaksgam branch of the Yārkand has its sources in the Urdok, Kyagar, and Gasherbrum glaciers of the Karakorum (*Records, Geological Survey of India*, LXII, p. 263), and it drains the Central Asian watershed at E, Chart XXXV. It was surveyed by Major Mason in 1926. (*Exploration Shaksgam Valley: Records, Survey of India*, XXII). The Shaksgam river, (called also Oprang) follows a long course north of the Karakorum parallel to the course of the Indus in Ladākh: under the name of Zarafshān, it passes through the Kun-lun mountains at their north-western termination, where they abut against the meridional range of Muztāgh Ata. It flows across the Takla Makān desert past the city of Yārkand, and after it has been joined by its Kāshgar tributary it is known as the Tārīm river. Like the river of Chitrāl the Yārkand river flows under many different local names, which are at times confusing.

The Karakāsh.

The Karakāsh river has its western sources in the Depsang-Karakorum immediately east of the Raskam. In the Depsang there exists a water-parting line between the Karakāsh and the Shyok river basins, which is part of the Central Asian divide, but further east the sources of the Karakāsh are on the ridge that borders the closed lake basin of Tibet. The following extract from a letter from Mr. Shaw, written in 1870, describes the place where the drainage of the Shyok and of the Karakāsh meets the closed basin of Tibet, Chart XXXV. Mr. Shaw wrote to Sir Roderick Murchison as follows (*Proceedings, R. G. S.* XV, 1870-71):—

"What was my astonishment after walking a few yards to find some water "trickling westwards towards the mountains. I had, therefore, already passed "the imperceptible watershed between the great river systems of the Indus and "of Central Asia. Beyond the lake we had just passed, the waters feed the "Karakāsh; while the trickling stream which I had reached pierces the great "limestone range, and much augmented on the way runs through rocky gorges "into the Shyok, which is one of the chief sources of the Indus."

"Thus the great water systems of southern and of Central Asia are here "separated by no gigantic mountain range, but merely by a few yards of level "sand, at a prodigious elevation it is true."

In 1901 Sir Aurel Stein surveyed the course of the Karakāsh, where it breaks through the northern and southern Kunlun ranges. The long longitudinal troughs of the Karakāsh illustrate the difficulty which the river had in finding an outlet into the desert of Takla Mākān. The Karakāsh is fed by glaciers east of Depsang and by others in the Kunlun.

The Yurungkāsh.

The Yurungkāsh has its sources in the glaciers of the Kunlun. It drains a trough, 100 miles long, between the two snow-capped ranges of Kunlun, before it finds an outlet of escape near the peak of Muztāgh (23,890 feet), the highest peak of the Kunlun (Chapter 16). The glaciers of the peak of Muztāgh contribute to the flow of the river. The course of the Yurungkāsh through the Kunlun range was surveyed in 1901 by Sir Aurel Stein with characteristic thoroughness. After the Yurungkāsh has emerged from the mountains, it flows by the city of Khotan, and in the desert it unites with the Karakāsh river. The united stream is known as the Khotan Darya.

The Keriya river.

The Keriya river rises in the glaciers of the South Kunlun and cuts its way through the North Kunlun range near and east of the high snow peak of Ghazi Kunghak. In the desert it passes the town of Keriya. It is a smaller river than the Yurungkāsh.

The Cherchen river.

The Cherchen river rises in the trough between the South Kunlun range and the Astin Tāgh range. It emerges from the Tibet mountains 230 miles east of the Yurungkāsh (Chapter 16).

The lake basin of the Tibetan plateau is narrow at its western extremity in Ladākh, and it gradually becomes wider further east. Of the rivers mentioned in this chapter the Yārkand is the westernmost and the largest; its basin is in contact with the basin of the Indus, and its sources are on the watershed of Central Asia. The Karakāsh, east of the Yārkand, is a smaller river than the Yārkand, but its basin is still in contact with that of the Indus, and some of its sources are still on the Central Asian watershed. The Yurungkāsh is smaller than the Karakāsh, and the Keriya and Cherchen are smaller still. The five rivers decrease in volume from west to east, as the Tibetan plateau widens: and their steady decrease in volume gives rise to the conjecture that the Tibetan plateau becomes more and more of a barrier to the moisture bearing currents from the Indian ocean, as its width increases. If this conclusion is

correct, it would appear that the rainfall of Northern Tibet comes from the Indian ocean, and not from the Pacific or Arctic, or from the Mediterranean sea.

The Lake of Lop Nor.

The following reference to the Lake of Lop Nor was made in this book in the 1907 edition, page 121 :—

"The rivers of Tārīm empty their waters into the lagoons of Lop Nor (see frontispiece to Part I). Sven Hedin has shown that whilst these lagoons are getting choked with sand, the desert on their north is being excavated by wind: their water, he says, will ultimately overflow and seek the lower level. This has happened before, and in 265 A.D. Lop Nor lay considerably north of its present position. As the lakes move, so do the vegetation, the animals, and the fisher-folk; and Sven Hedin calls Lop Nor the oscillating pendulum of the Tārīm river."

It was in the year 1900 that Sven Hedin had first discovered in the northern part of the desert the ruins of a former town; these ruins were 70 miles north of Lop Nor. In one of the ruined houses he had found manuscripts which had revealed the fact that this old town was Loulan.

In A.D. 265 Loulan had been a flourishing city near the lake of Lop Nor: and in those days a great road, used for the transport of silk merchandise, passed through Loulan from Pekin to Rome. At a later date the Tārīm river had changed its course, and the lake of Lop Nor had shifted to the southern part of the desert. Deprived of its water Loulan had become a deserted ruin, and the road to Rome had been abandoned.

In 1903 after having undertaken levelling operations across the desert from south to north, Sven Hedin recorded the following prediction (*Central Asia and Tibet*, II, 174) :—

"I am convinced," he wrote, "that in a few years time the lake of Lop Nor "will be found in the locality where it was formerly."

In 1905 he again wrote "It is not too bold a thing to say that in a short "time the river Tārīm *must* go back to the old Kuruk-darya bed." "It is merely "a question of time: the river will be forced to return to its northern bed. The "lower limb of the Tārīm river oscillates backwards and forwards like a pendulum, "the periodic time of each oscillation amounting to 1,500 years."

In 1921 the Tārīm river did swing back to its old bed of A.D. 265, and the lake of Lop Nor began once more to shift northwards (*Across the Gobi desert*, by Sven Hedin, translated by H. J. Cant, 1931). When Sven Hedin first made his predictions in 1903 it was thought that he was basing them on insufficient data. But the fulfilment of his prophecy shows now that his understanding of the problem had been correct.

THE SPELLING OF THE NAME KARA-KASH.

Geographers have always spelt the name Kara-Kash as Kara-Kash, whilst linguists have spelt it as Qara-Qash. The letter Q is common in Turki and Arabic words. Sir George Grierson writes, "In Shaw's dictionary of Turki "there are 24 pages of words beginning with Q, and nearly all these are pure Turki, "not borrowed from Arabic." Shaw's dictionary was published half a century ago but the early geographers (relying upon the pronunciation of the Turcomans and upon their own understanding of that pronunciation) spelt the name as Kara-Kash. When a name becomes established in history and geography, it is difficult to break away from it. The trouble is due to the existence in Arabic and Turki of two distinct K sounds; when these sounds are converted into writing, they are kept apart by the use of different K symbols. In European languages there is only one K symbol. It would have been simpler for geography if linguists had invented a second European K for purposes of transliteration, but instead of adopting this course they fell back upon the expedient of making the European Q serve for the second Turki K: this employment of the letter Q is of use in dictionaries and translations, but it has not been altogether advantageous upon maps. Transliterators, who are guided only by rules may not appreciate geographical difficulties, but linguists do recognise that in geography there is an historic side to these questions as well as a scientific side. A certain amount of resentment was felt some years ago by army officers when the name Kandahār was spelt upon a map as Qandahār.

In his maps of Tibet and Turkistān, 1918, Sven Hedin spelt the name as Kara-Kash, and in his Memoir on the maps of Chinese Turkistān, 1923, Sir Aurel Stein spelt the name as Kara-Kash. Both these authorities were Turki linguists, and both thought it advisable to adhere to the traditional geographical spelling. In this book I have followed their example and have used the letter K.

In Turki the prefix Kara, meaning black, is common: there is the Kara-Kul (Qara-Qul) lake, meaning the stormy lake, and the Kara-Kash (Qara-Qash) river, a poetic name meaning "black eye-brows." If the name Kara-Kash were standing alone, geographers could accept the spelling Qara-Qash. But the Kara-Kash river rises near the Kara-Korum pass, and it seems inconsistent to spell Kara-Kash with a Q, and Kara-Korum with a K when the two names are close together on the map.

The Karakorum pass has been one of the best known passes in Asia for many centuries: its name is pronounced in India with the ordinary K: Indian surveyors who have crossed this pass pronounce its name with the ordinary K. The name "Karakorum pass" is now an Indian name, and has become Indianized. We have to recognise and accept the Indianized forms of border names. The Survey of India cannot spell the Indian name Kara-Korum in such an unnatural way as Qara-Qorum.

But the arguments adduced in favour of the spelling Kara-Korum do not hold good in the case of the name Kara-Kash. The Kara-Kash river is beyond the watershed of the Indus, and is not an Indianized name. The only argument against spelling this name as Qara-Qash is the argument of consistency: but I do not think that Indian geographers can press the argument of consistency, for if they do so, they will be ousting the symbol Q from Turki geography. If we insist on spelling Kara-Kash with the ordinary K, because Kara-Korum is spelt with a K, we shall have to carry consistency further and spell Yurung-Kash with a K instead of Yurung-Qash: and so we shall be led to spell the Kara-Kul lake with K instead of Q.

I think therefore that we should continue to spell the border name Karakorum with K, because it is now an Indian name, but that we should spell the Turki name Qara-Qash with Q, because it is on the Turki side of the border. This solution will I think meet with the approval of linguists.

CHAPTER 27.

THE RIVER-GORGES OF THE HIMĀLAYA.

There is hardly a mountain range in Asia that has not been cut across by a river. A river which has been flowing for miles along an open trough between two parallel ranges will suddenly bend and piercing one of the ranges will escape through a precipitous gorge. (*The River valleys of the Himālayas, an address to the Manchester Geographical Society*, 1893, by R. D. Oldham. *The evolution of Indian Geography*, by R. D. Oldham, *Geographical Journal*, March, 1894.)

The lengths and depths and forms of the stupendous gorges, through which the rivers of Asia pass the mountain ranges, have excited the wonder of all travellers who have seen them: the extraordinary narrowness of the defiles, the perpendicularity of their walls and the immense difference of altitude between the beds of the rivers and the peaks towering immediately above them have given to these wonderful chasms an absorbing geographical interest.

In many instances a range is found to possess the same form and character on the two sides of a river-gorge intersecting it, but in others it appears to undergo a complete change. No difference can be observed, for example, in the shape or height or alignment of the Pīr Panjāl range on the two sides of the gorge of the Jhelum, and the Great Himālayan range itself does not change its form at the passage of the Arun Kosi. But at its intersection by the Sutlej the change in the great range is so complete that it is difficult to trace a connection between the mountains on either side of the gorge.

Many controversies have arisen over the origin of the great river-gorges. A century ago the explanation generally accepted was that earthquakes or other convulsions had produced long fractures through the mountains, and that the rivers had found their way along the cracks; but subsequent examinations of rocks below the beds of gorges so frequently showed no signs of fractures, that it is now generally acknowledged that the gorges have been slowly carved by the rivers themselves during the course of ages.

Though, however, the defiles of many rivers are unconnected with transverse fractures, yet a certain few, among which the Alaknanda is one, are now known to follow the lines of geological faults; even in these cases, however, the gorges have been carved mainly by water and an original structural weakness was merely the determining cause of the position of the gorge in the beginning.

A gorge may be carved by water across a range in many different ways. Firstly, as a new-born range is rising slowly out of the ocean, it may be cut across at intervals by the sea and divided into a series of islands; the channels cut thus in early times may subsequently develop into river-gorges. Secondly, the snow and rain falling on the front slopes of a range may create glaciers and rivers, which slowly cut back by head-erosion and eat through the mountains. Thirdly,

the snow and ice accumulating on the crest may gravitate towards the lowest points of the range, and thence flow off in opposite directions and wear away the rock on both flanks simultaneously. Fourthly, a river may be antecedent or older than the mountains, and have maintained its path across the latter as they rose. Fifthly, the flow of a river may be dammed by the rise of mountains across its path, and the waters of the lake so formed may eventually overflow and carve a gorge across the barrier range.

From classifications of the known gorges of Asia geographers were led to believe that the drainage of numerous mountain basins has been dammed by the rise of recent ranges and that the imprisoned water has risen and overtopped the crests and has eroded narrow channels in its escape. But owing to the entire absence of lacustrine deposits, geologists have been unable to accept this explanation. In view of the differences of opinion that are now existing, we cannot presume in this paper to put forward any theory accounting for the presence of the gorges. The courses of rivers across ranges may have originated, some in one way, some in another, and even a single gorge may have been partly due to one cause and partly to others. "Nothing can be certain till the topography and the geology are better known": (*vide The Valleys of the Himālayas*, by R. D. Oldham, *Geographical Journal*, November, 1907).

The charts of rivers bring home to us how different are the forms of basins. On the one hand we see the Kosi, the Karnāli and the Gandak possessing numerous branches and draining immense lengths of the snowy range, and on the other we witness the Sutlej a branchless trunk issuing from Tibet and draining a narrow transverse zone of the Himālaya.

The following table shows the heights of the beds of the principal gorges through the Great Himālayan range and the widths of those gorges at certain heights :—

TABLE XV.

River-gorge.	Height of bed of gorge in feet near the axis of the range.	Width of gorge between commanding peaks.	Average fall per mile from peak to bed.
Kāli Gandak . .	5,000	12 miles at 24,000 feet	3,167 feet
Bhote Kosi . .	5,000	10 miles at 20,000 feet	3,000 feet
Bhāgīrathi . .	7,000	11·5 miles at 20,000 feet	2,261 feet
Dudh Kosi . .	16,000	14 miles at 22,000 feet	857 feet
Sutlej . . .	9,000	9 miles at 20,000 feet	2,444 feet
Trisūli Gandak .	6,000	16 miles at 19,000 feet	1,623 feet
Buri Gandak . .	7,000	18 miles at 19,000 feet	1,333 feet
Kāli . . .	9,000	6 miles at 16,000 feet	2,333 feet
Gori . . .	10,000	6 miles at 16,000 feet	2,000 feet
Arun . . .	6,000	14 miles at 16,000 feet	1,429 feet
Tīsta . . .	6,000	25 miles at 16,000 feet	800 feet
Alaknanda . .	6,000	30 miles at 16,000 feet	666 feet

The proximity of high peaks to deep gorges.

The passage of a river across a range has been observed to occur in many places near the highest point of the range, but our knowledge of the Himālaya mountains is insufficient to justify any statement of a general law. Some supreme summits do not appear to stand on the edges of transverse gorges, and some of the gorges do not appear to have been cut on the flanks of great peaks, yet proximity has been so often noticed that it must now be regarded as a phenomenon deserving attention.

It may be that the great outbursts of granite, which go to form the high peaks, are frequently accompanied by lines of weakness in the original structure, and that whilst the peaks themselves are hard, the rocks on their flanks have feeble powers of resistance.

It may be that the high peaks have from early times, before the mountains attained their present elevation, condensed the moisture of southern breezes and caused more snow and rain to be precipitated in their vicinity than on other parts of the range, and have thus given to glaciers and streams not only a greater fall and a greater eroding power, but a greater volume.

It may be that, as one portion of the earth's crust becomes elevated to a great height, an adjacent portion becomes depressed, in accordance with the theory of isostasy.

It may be that the highest points of ranges occur at the bends and bifurcations of the latter, and that the bays and angles formed by bends and bifurcations render such places liable to the attacks of glaciers and streams. At present we are unable to determine the cause, and the solution of the problem awaits further and more accurate observations.

The following table contains a few examples of the proximity of extreme heights and depths: all the peaks included in the table are the highest points of their respective regions.

Table XVI.

River.	Height of bed of gorge near the peak.	Range.	Peak.	Height of peak.	Horizontal distance from peak to bed.	Fall per mile from peak to bed.
	Feet			Feet	Miles	Feet
Sutlej	10,000	Zāskār	Riwo Phargyul	22,210	4½	2,713
Kāli Gandak	5,000	Great Himālaya	Dhaulāgiri	26,795	4	5,449
Arkari	10,000	Hindu Kush	Tirich Mīr	25,263	8	1,926
Indus	4,000	Great Himālaya	Nanga Parbat	26,620	14	1,616
Hunza	6,000	Haramosh	Rakaposhi	25,550	9	2,172
Dudh Kosi	18,500	Great Himālaya	T 42	25,433	4	1,733
Gori	10,000	Great Himālaya	Nanda Devi	25,645	12	1,304
Yurungkāsh	11,000	Kunlun	Muztāgh	23,890	10	1,289
Manās	10,000	Great Himālaya	Kula Kangri	24,784	16	924
Tsangpo	8,000	Great Himālaya	Namcha Barwa	25,445	8	2,182

THE HIGHEST POINTS OF RANGES TEND TO OCCUR ON TRANSVERSE LINES.

In the last paragraphs we dealt with the phenomenon of contrast: in this we refer to the phenomenon of sympathy. The contrasts were between neighbouring points of the same range, the sympathies are between corresponding points of different ranges.

The several parallel ranges of the Himālaya and Tibet tend to culminate in sympathy with each other: we give the following instances to illustrate our meaning.

(i) The Karakorum culminates in K^2 opposite to the Pīr Panjāl, which is the highest section of the outer Himālaya. The intermediate ranges culminate in Nanga Parbat, and Haramosh, between K^2 and the Pīr Panjāl.

(ii) The Chaur peak, the highest of the Nāg Tibba range, stands opposite to the great Zāskār peak, Riwo Phargyul and to the Aling Kangri of Tibet.

(iii) A further example of sympathetic expansion we find in the Kumaun Himālaya. Here the culminating point of the great range is Nanda Devi; on a line at right angles to the range stands Kailās, the culminating point of the Kailās range; south-east of this line is Gurla Mandhāta and north-west is Kāmet, the highest peak of the Zāskār range. Thus we see that four ranges tend to increase in elevation within the same region.

THE LOWEST POINTS OF RANGES TEND TO OCCUR ON TRANSVERSE LINES.

The above are examples of sympathetic maxima, and Chart XXXVI has been drawn to illustrate sympathetic minima, and to show how the gorges or lowest points of ranges tend to occur on transverse lines.

The following table will explain the meanings of the letters inserted on Chart XXXVI.

TABLE XVII.

A 1	The Indus turns the Great Himālaya west of Nanga Parbat.
A 2	The Hunza river turns the Karakorum north-west of Rakaposhi.
B 1	Passage of the Jhelum through the Pīr Panjāl range.
B 2	Passage of the Indus through the Ladākh range.
B 3	Shingshāl pass.
B 5	Passage of the Yārkand river through the Kunlun range.
C 1	The Chenāb crosses the Lesser Himālayan range.
C 2	The Zoji pass.
C 3	The Shigar river crosses the Zāskār range.
C 4	The Indus crosses the Ladākh range.
	Karakorum pass.
C 5	The Karakāsh crosses the Kunlun range.

TABLE XVII—*contd.*

D 1	The Chenāb cuts through the Pīr Pānjal range.
D 2	The Zāskār river cuts through the Zāskār range.
D 4	The Yurungkāsh river cuts through the Kunlun range.
E 1	The Beās cuts the Siwālik range.
E 2	The Rāvi cuts the Dhaula Dhār range.
E 3	Great bend in the Zāskār river.
E 4	The Shyok river cuts the Karakorum range.
F 1	The Sutlej passes the Siwālik range at an overlap.
F 2	The Beās passes the Dhaula Dhār range.
F 3	The Spiti-Indus water-parting bends through a right angle.
F 4	The Indus breaks through the Ladākh range.
	The Pangong line of lakes bends in sympathy with the Indus.
F 5	The Keriya breaks through the Kunlun range.
G 1	The Jumna passes the Siwālik range.
G 2	The Sutlej crosses the Great Himālaya.
G 3	The eastern branch of the Indus crosses the Kailās range.
H 1	The Ganges passes the Siwālik range.
H 2	The Ganges (Bhāgīrathi) crosses the Great Himālaya.
H 3	The Sutlej crosses the Zāskār range.
K 1	The Alaknanda crosses the Great Himālaya.
K 2	The Sutlej crosses the Ladākh range.
L 1	The Kāli Gandak cuts the Himālayan range east of Dhaulāgiri.
L 2	The Phuto pass, 15,080 feet, over the Ladākh range.
M 1	Knee-bend at junction of the Trisūli Gandak and Kāli Gandak.
M 2	Southward bend in the Brahmaputra.
	The Bāghmati passes the Siwālik range opposite the Bhote Kosi's passage through the great range. (Charts XXVII and XXVIII.)
P 1	The Arun Kosi breaks through the Great Himālaya, Lesser Himālaya and Siwālik range on one alignment.
P 2	The Brahmaputra cuts northwards through a branch range.
Q 1	The Ganges and Brahmaputra break between the mountains of Chota Nāgpur and Assam.
Q 2	The Siwālik range is destroyed.
Q 3	Bend in the Great Himālaya between Kānchenjunga and Chomo Lhāri.
Q 4	The Nyang tributary of the Brahmaputra breaks the Ladākh range.
Q 5	Northern tributary of the Brahmaputra cuts the Nyenchen-tang-lha.

It will be held that many of the above so-called examples of sympathy are but coincidences, and doubtless this is the case: but the total accumulation of evidence is considerable, and can hardly be dismissed as a series of accidents.

The higher range of a trough is generally the one pierced by the escaping drainage.

When a river breaks out from a trough, the range that is pierced is generally the higher of the two: rivers, for example, that rise in the Sarikol trough, escape through the higher range to the east; those that rise in the Hindu Kush trough, with the exception of two minor streams, escape through the higher range to the south; those that rise behind the Kunlun escape through the higher range to the north; those that rise north of the Great Himālaya escape, with one exception, through the higher range to the south.

If it could be proved that the river-gorges in these cases had been caused by the overflows of imprisoned lakes, it would become evident that the higher ranges were younger, and were, at the times when the overflows were commencing, lower than their parallel companions, which they now surpass.

CHAPTER 28.

THE LAKES OF TIBET AND TURKISTĀN.

If we examine Chart XXIII, which illustrates the basins of the great rivers that drain the plateaux of Asia, we find that in addition to the low-lying self-contained basin of Tārīm, there is beside it a very large high-level basin in Tibet, which possesses no outlet for drainage.

Throughout the Tien Shan, the Pāmirs and the Himālaya there are inland basins without outlets, but no one of them approaches in size the lake-basin of Tibet, or is indeed large enough to be shown on such a small scale as that of Chart XXIII.

Though the Tibet lake-basin is very extensive and is studded throughout with lakes, it contains no single lake that will compare in area with the great lakes of the world.

The area of lake Superior in America is 30,000 square miles; the area of the Sea of Aral is 25,000 square miles; the areas of the Asiatic lakes Balkash and Baikal are respectively 9,000 and 10,000 square miles.

The largest lake enclosed among the high mountains of Asia is Issiq Kol in the Tien Shan, area 2,000 square miles. The largest lake of Tibet is Koko Nor, area 1,630 square miles.

In the following tables are given the heights, areas, lengths, and (when available) the depths of the principal lakes of Tibet and Turkistān. Many hundreds of lakes have been discovered by explorers in High Asia, but the greater number possess areas of ten or fifteen square miles only, and have been excluded from the lists. The names of small lakes have, however, been included for those regions in which no large lakes exist. In the Karakorum and Hindu Kush there are no lakes of importance.

TABLE XVIII.—THE PRINCIPAL LAKES.

Region.	Name.	Area in square miles.	Altitude above the sea in feet.
TIEN SHAN	Issiq Kol	2,000	5,300
	Sairam Nor	200	5,900
	Son Kul	102	9,400
	Chadir Kul	82	11,195
TĀRĪM BASIN	Baghrash Kul	630	3,400
	Lop Nor (northern)	150	2,600
	Lop Nor (southern)	220	2,590

TABLE XVIII.—THE PRINCIPAL LAKES—*contd.*

Region.	Name.	Area in square miles.	Altitude above the sea in feet.
PĀMIR REGION	Great Kara Kul	140	13,430
	Rang Kul	61	12,700
	Yeshil Kul	30	12,460
	Sir-i-Kul (Lake Victoria)	30	13,398
	Little Kara Kul	10	12,201
	Chakmaktin	8	13,021
KUNLUN MOUNTAINS	Ayagh Kum Kul	250	11,710
	Achik Kul	240	..
PUNJAB HIMĀLAYA: (on the Tibetan side of the crest-line).	Tso Morari	46	15,000
	Tso Kyagar	..	15,690
	Tso Kar	..	15,684
PUNJAB HIMĀLAYA: (on the Indian side of the crest-line).	Wular	44	5,187
	Dal	8	5,200
KUMAUN HIMĀLAYA	Naini Tāl (A group of small lakes).	..	6,400
NEPĀL HIMĀLAYA: (on the Tibetan side of the crest-line).	Palgu Tso	40	15,000
	Tsomo Tretung	40	14,000
NEPĀL HIMĀLAYA: (on the Indian side of the crest-line).	Khewan Tāl	6	..
	Damodar Kund	2	..
	Gum Chu	5	..
	Dudh Kund	5	..
ASSAM HIMĀLAYA	Nera Yu Tso	..	..
SOUTHERN TIBET	Mānasarowar	200	14,900
	Rakas Tal	140	14,850
	Gunchu	40	15,800
SOUTH-EASTERN TIBET LAKE BASIN, south of Tsangpo.	Yamdrok	340	14,350
	Trigu	51	15,500
	Pomo	20	16,195
	Pa Tso	20	14,500
	Dumo	..	..

TABLE XVIII.—THE PRINCIPAL LAKES—*concld.*

Region.	Name.	Area in square miles.	Altitude above the sea in feet.
EASTERN TIBET north of Tsangpo.	Yigrong	10	7,300
TRANS-HIMĀLAYA . .	Tengri Nor	950	15,190
	Selling	720	14,000
	Dangra Yum	500	15,500
	Teri-Nam	350	15,200
	Kyaring	290	15,800
	Ngang-Glaring . . .	250	15,500
	Ngantse	250	15,300
	Naktsong	230	..
	Tarok	180	15,000
	Bum	140	15,000
	Mokieu	140	..
	Tashi Bup	50	..
	Tong-Ka	50	..
LADĀKH	Pangong	230	13,930
NORTH-WESTERN TIBET .	Lighten	250	16,500
	Tsaggar	100	..
	Arport	100	17,200
NORTHERN TIBET . .	Markham	100	16,200
	Hermiones	200	16,000
NORTH-EASTERN TIBET .	Koko Nor	1,630	10,700
	Oring Nor	250	13,700
	Dsharing Nor	220	13,700

Many of the lakes of this table, such as Yamdrok, Mānasarowar and Koko Nor, though situated in Tibet, lie outside the Tibet lake-basin.

The principal *extinct* lake of Tibet is the Tsaidam depression; it is 300 miles long, and its trough is 100 miles broad, and 40 miles broad on the flat; it possesses an area of 12,000 square miles of salt desert at an elevation of 9,000 feet.

It is interesting to note that throughout the Continent of Asia, there is no water-parting line between the Indian and the Arctic Oceans; instead of an

elevated line crossing the central portion of the continent from east to west there is a succession of closed basins:—the Tibet lake-basin, the Tārīm basin, the basin of Lake Balkash, the basin of the Helmand, the Aral basin, and the Caspian.

No range of mountains can be found—not even a single peak—from which the water flows on one side into the Indian Ocean and on the other into the Arctic. The absence of a continental divide is probably due to the great distance and to the mountain barriers, which intervene between Central Asia and the sea. If the moisture-laden winds from the Arctic, Pacific and Indian Oceans could penetrate and give heavy rains to Central Asia, the volumes of the Tārīm, Helmand, Oxus, and Jaxartes would be increased, and outlets to the sea would be forced.

CHAPTER 29.

ON THE ORIGIN OF LAKES.

The Tibetan Lakes.—Until comparatively recently the origin of the lakes of Tibet was ascribed to the damming of river valleys by the talus fans of their tributaries; this hypothesis, which was put forward by Mr. Drew (*Jummoo and Kashmīr territories*) to explain the origin of such lakes as Pangong and Tso Morari in Ladākh, and has even been extended to the valley of Kashmīr, was based on the fact that in all cases the visible barriers of the lakes are composed of detrital matter. It was, however, pointed out by Mr. R. D. Oldham that, under normal circumstances, a main stream would in all probability be able to keep its channel open and that unless supplemented by other causes the mere deposition of talus could hardly be considered adequate. If, however, elevation of the river-bed were to take place at a rate greater than the rate of erosion of the river, a barrier would be formed and eventually a talus dam would accumulate across the valley (*Records, Geological Survey of India*, Vol. XXI (1888), p. 156).

That certain lakes in Tibet have been formed in the manner suggested by Mr. Oldham, seems to us probable, and the curious reversal of drainage recorded by the writer at the head of the Rong Valley in Central Tibet seems only capable of explanation on the assumption of a rise of the valley-bottom near the former outlet of Yamdrok Tso (H. H. Hayden: *Memoirs, Geological Survey of India*, Vol. XXXVI, pt. 2), but it is doubtful whether this or indeed any other hypothesis can be of general application.

In some cases, as for instance in that of Kala Tso, a lake would appear to have been clearly caused by the damming of a valley by extensive moraine material brought down by a glacier from the neighbouring mountains, and it is probable that in many cases the lake dams must be attributed to glaciers rather than to rivers.

By a slight modification of Mr. Drew's hypothesis it seems, however, that the origin of many of the Tibetan lakes might be explained without the necessity for assuming concomitant crustal movement. It has been objected by Mr. Oldham that a river would most probably be able to keep its channel open in spite of the material brought down by its tributaries. One of the most marked features in connection with the development and growth of a river system is the tendency of certain branches to grow at the expense of others by cutting into or "capturing" their drainage areas and even by actually tapping a neighbouring tributary at some point in its course; this latter process is known as "beheading". If, therefore, either owing to the beheading of the main stream or to its own vigorous growth by capture, a tributary were to become the predominant affluent

of a river system, then owing to its increase of volume and consequent increase of transporting power the amount of material brought down by it would be correspondingly increased. If at the point where it debouched into what was formerly the main valley, the latter were broad and open, its rate of flow would be checked and the transported material might thus be deposited to form a dam across the valley. Such might indeed have been the origin of Tso Morari in Rupshu, the formation of which has been ascribed by Mr. Oldham to an elevation of the river-bed at a point below the present dam. This principle, however, would not apparently be applicable to Pangong. Here a long and narrow valley holds a series of lakes, which were ascribed by Mr. Drew to dams built up by tributary streams; this hypothesis has been rejected not only by Mr. Oldham, but also more recently by Mr. Ellsworth Huntington ("Pangong: a glacial lake". *Journal of Geology*, Vol. XIV (1906), p. 599) who regards the valley as a true rock-basin carved out by a glacier. Such lakes are not uncommon in other parts of the world, but, with the exception of the small lakes in the Kumaun Himālaya, none of those in the Himālaya or Tibet have been hitherto attributed to this cause.

Thus for the mode of origin of the Tibetan lakes, three hypotheses have been put forward:

(1) the damming of the main valley by the fans of tributaries (*Drew*);
(2) rise of the river-bed and consequent deposition of material above the barrier so formed (*Oldham*);
(3) the filling of a rock-basin previously scooped out by a glacier (*Huntington*).

The further suggestion, now made by us, that the damming of the main valley may have taken place owing to its conversion into a tributary valley may be regarded as a modification of Mr. Drew's hypothesis, and if we add to this the damming of tributary valleys by moraines of glaciers occupying the main valley, we shall probably have included all the causes at work to form the more important lakes of Tibet. But we are not disposed to think that any single theory can be of universal application: thus Kala Tso may be regarded as a type of the first hypothesis (with its corollaries), Yamdrok Tso of the second and, according to Mr. Huntington, Pangong is a type of the third.

Glacial Tarns.—We have not yet referred to the innummerable tarns found throughout the higher still glaciated valleys; these, however, offer no difficulties; they are, in almost every instance, merely ponds, each caused by the damming up of its valley by the terminal moraine of a retreating glacier.

The Kumaun Lakes.—Turning now from the Tibetan uplands to the lower valleys of the Himālaya, we find in Kumaun, nestling among the forest-clad hills, a small group of lakes of which Naini Tāl and Bhīm Tāl are the best known. Their size is insignificant, but they are of interest owing to the rarity of such

lakes in the Himālaya. Many theories have been propounded to explain their origin; they have been ascribed to glaciers, to landslips, such as that which caused the formation of the famous Gohna lake in 1894 (T. H. Holland: *Records, Geological Survey of India*, Vol. XXVII (1894), pt. 2), to faulting or other earth movements and lastly to removal, by solution, of the underlying rock. The first of these theories has now been generally discarded; the second applies to Khurpa Tāl and other small lakes near Naini Tāl; but the origin of Naini Tāl itself still remains uncertain and may be due either to the elevation, by sudden faulting or by slow and gradual rise of the crust, of part of the lower end of a pre-existing valley, or to the gradual eating away, by percolating water, of the limestone underlying the central part of the valley: by this latter process would be formed cavities and "swallow-holes", which gradually becoming enlarged to underground caves would lead to a collapse of the surface over a considerable area; such a process is common when the prevailing rock is limestone and may be observed on a small scale in many places in the hills around Naini Tāl. (C. S. Middlemiss: *Records, Geological Survey of India,* Vol. XXIII (1890), p. 228).

The last lakes to which we have to refer are those of the valley of Kashmīr. Here we find a great alluvial flat through which the Jhelum meanders in its sluggish bed till it falls into the Wular lake at its south-eastern corner. Seen from the high hills to the north, this lake looks like a mere inundated corner of the great Srīnagar plain, and with its marshy borders bears a most striking resemblance to the typical "jhil" or "bhil" so common in the alluvial plains of Bengal. By Mr. Oldham, this small and shallow lake, as also that of Dal in the neighbourhood of Srīnagar, was regarded as an inundated hollow in the alluvial plain, and this theory has been supported by Dr. Karl Oestreich in his recent paper on the valleys of the North-West Himālaya. [*Petermann's Mitteilungen, Erg. No.* 155 (1906)].

Dr. Oestreich, however, goes a step further than Mr. Oldham and attributes their formation to deposition of alluvial dams by the Jhelum, thus increasing the analogy to the *bhils* of the Gangetic plain.

Desiccation of lakes.—That the lakes of Tibet were once very much larger than they now are is almost universally admitted [*A Manual of the Geology of India, 2nd Edn.*, p. 486. F. Drew: *Jummoo and Kashmīr territories,* pp. 292-300. R. Lydekker: *Memoirs, Geological Survey of India,* Vol. XXII, p. 28. *Journal, Royal Geographical Society,* Vol. XLVII (1877), p. 107]. This has been inferred from the salt-covered flats and dry basins which are so common on the plateau of Tibet, as well as from the old beaches seen on the hill-sides far above the present water-level, which show that the lakes once stood many hundred feet higher and spread over much larger areas than they occupy at the present day.

Thus it has been recorded by almost all explorers who have visited the great lake-basin of Tibet (G. R. Littledale: *Geographical Journal*, Vol. VII (1896), p. 474; H. H. P. Deasy: *In Tibet and Chinese Turkistan*, p. 32; C. G. Rawling: *The Great Plateau*, p. 110) that almost every individual lake is surrounded by old terraces extending to as much as 200 feet above the present water-level. This feature, too, is clearly visible on the shores of the lakes nearer to India, such as Tso Morari, Kala Tso, Yamdrok (H. H. Hayden: *Memoirs, Geological Survey of India*, Vol. XXXVI, pt. 2) and Pangong (Ellsworth Huntington: *Journal of Geology*, Vol. XIV (1906), p. 599), of which the last shows a large series of old beaches, which remain as records of the rise and fall of the level of the lake. Much interesting information may be gleaned from these old lake terraces and in the case of Pangong, Mr. Huntington regards them as evidence of desiccation, it is true, but of a desiccation that was oscillatory, embracing periods "now "drier, now wetter, but the tendency to aridity generally greater than its "opponent."

That the marked contraction in volume of the lakes is due in many cases to evaporation is proved by the intensely saline character of their waters and, like the decrease of the glaciers, it has been attributed to a gradual process of desiccation consequent on the rise of the Himālayan ranges (R. D. Oldham: *Records, Geological Survey of India*, Vol. XXI (1888), p. 157). That very extensive desiccation has occurred, since the period of greatest extension of the glaciers and the (possibly subsequent) great extension of the lakes, may be safely regarded as an established fact, but whether such a process is still operative is a question which can only be decided by regular and systematic observations extending over long periods of time. The isolated observations made by explorers during the last hundred years in various parts of Tibet are inconclusive, as well as being at times mutually contradictory. This is especially noticeable with regard to two features, outflow and salinity.

It has been generally observed that most Tibetan lakes have no superficial outlet, but at the same time it is by no means unusual to find that there is a well-marked channel through the old river gravels which fill the former outlet, and that this channel, though dry at present, shows evidence of outflow having taken place at no very distant date; such channels are to be seen—to cite the more familiar instances—on Mānasarowar in Nari Khorsam, and on Tsomo Tretung and Kala Tso in Tsang. The well-preserved state of these channels shows that either they have only recently become dry or that they are still in intermittent use and the fact that the accounts of different explorers regarding the same channel are often mutually conflicting rather lends colour to the latter alternative. Hence the presence of a dry channel cannot be taken as conclusive proof that desiccation is still in progress, especially as in certain cases—as for instance from Kala Tso—outflow takes place beneath the surface of the deposits through which the superficial channel runs.

Similarly, although the fact that the waters of a given lake are salt may be taken as proof that desiccation has been operative, yet any attempt to establish the continuance of this tendency at the present time is frustrated by the want of systematic observations. This is, in fact, even more noticeable with regard to the salinity than in the case of observations regarding outlets. There is no doubt that many lakes, especially the smaller ones—such as Kyagar Tso and the salt lake of Ladākh,—are permanently and very markedly salt, but in many others the salinity varies in the most striking manner, water found quite undrinkable by one explorer having been subsequently regarded as perfectly fresh by another: a particularly good example of this peculiarity is furnished by the Aru Tso, which lies in Western Tibet due east of Leh.

This lake was visited in 1891 by Captain Bower (H. Bower: *Across Tibet*, p. 35), who writes that the waters were "salt of course, like all the Tibetan lakes". In 1897, Captain Deasy (H. H. P. Deasy: *In Tibet and Chinese Turkistān*, p. 31) remarked that the water was "drinkable", whereas in 1903 it was found by Captain Rawling (C. G. Rawling: *The Great Plateau*, p. 111) to be "without "the slightest flavour of salt or soda".

It is evident, therefore, that this character is largely dependent on seasonal variations * and, unless proved to be permanent, cannot be regarded as evidence of *progressive* desiccation.

Admitting, however, that desiccation has occurred to a very great extent in the past, it remains to be proved whether or no it is still operative. This can only be ascertained by systematic observations of the water-level and salinity of certain selected lakes. If we are correct in ascribing the observed desiccation to decreased rainfall due to the rise of the Himālaya, it is evident that if such rise is still in progress and if the rate of elevation exceeds the rate of degradation, then a steadily decreasing amount of moisture will reach the plateau of Tibet; that is to say, if the Himālaya as a mountain system have not yet reached maturity, it is to be expected that desiccation will still be in progress. When, however, this stage has been reached, it may be expected that the rainfall of Tibet will become approximately constant and such variations as may be observed will be of merely seasonal significance, and when, finally, degradation outweighs growth and the Himālaya pass into a stage of decay, the climate of Tibet will become increasingly moist and the lakes and glaciers will regain some measure of their former grandeur. In this connection observations have recently been begun by the Trigonometrical Survey from selected stations near Dehra Dūn with a view to determining the absolute values of Himālayan heights and thus eventually to detect any variations that may have taken place in the heights

* It has also been pointed out by Mr. Ellsworth Huntington that salinity is largely affected by circulation of the water in a lake and a single observation might thus be entirely misleading: see '*Pangong: a glacial lake*'. *Journal of Geology*, Vol. XIV (1906), p. 599.

of the great peaks: but it must be remembered that geological processes are usually so gradual as to be almost imperceptible during such periods of time as can be measured by human standards and the many disturbing factors, already referred to in a previous part of this paper, may render it impossible to detect with certainty such movement as may take place in the course of a single century.

Although the hypothesis of a rise of the Himālaya may fully suffice to account for the desiccation observed in the neighbourhood of the mountains and in the great lake-basin of Tibet, it is by no means certain that it can be applied to such areas as the Tārīm basin. The disappearance of lakes in this and similar desert areas, such as Baluchistān, has been attributed to the increase and movements of blown sand (S. G. Burrard: *Report on Geography to the Board of Scientific Advice for India,* 1905-06). The surface rocks of Tibet are everywhere decomposing and the several rivers that have their sources in Tibetan glaciers carry down immense loads of sand. The annual additions of sand to the deserts of Asia are always increasing the amounts already accumulated in past centuries. The Tārīm basin is becoming choked with sand; almost all its rivers now end in its deserts and fail to reach Lop Nor. The sand is always increasing whilst the water is not.

CHART XXIII

INDEX CHART

showing CATCHMENT AREAS of the HIMĀLAYAN and TRANS-HIMĀLAYAN RIVERS and LAKES.

Scale 1 Inch = 256 Miles.

Reference Number to Himālayan Rivers.

I	Jumna
II	Ganges
III	Rāmganga
IV	Kāli
V	Karnāli
VI	Rāpti
VII	Gandak
VIII	Bāghmati
IX	Kosi
X	Tīsta
XI	Raidāk
XII	Manās
XIII	Brahmaputra
XIV	Sutlej
XV	Beās
XVI	Rāvi
XVII	Chenāb
XVIII	Jhelum
XIX	Indus
XX	Mānasarowar

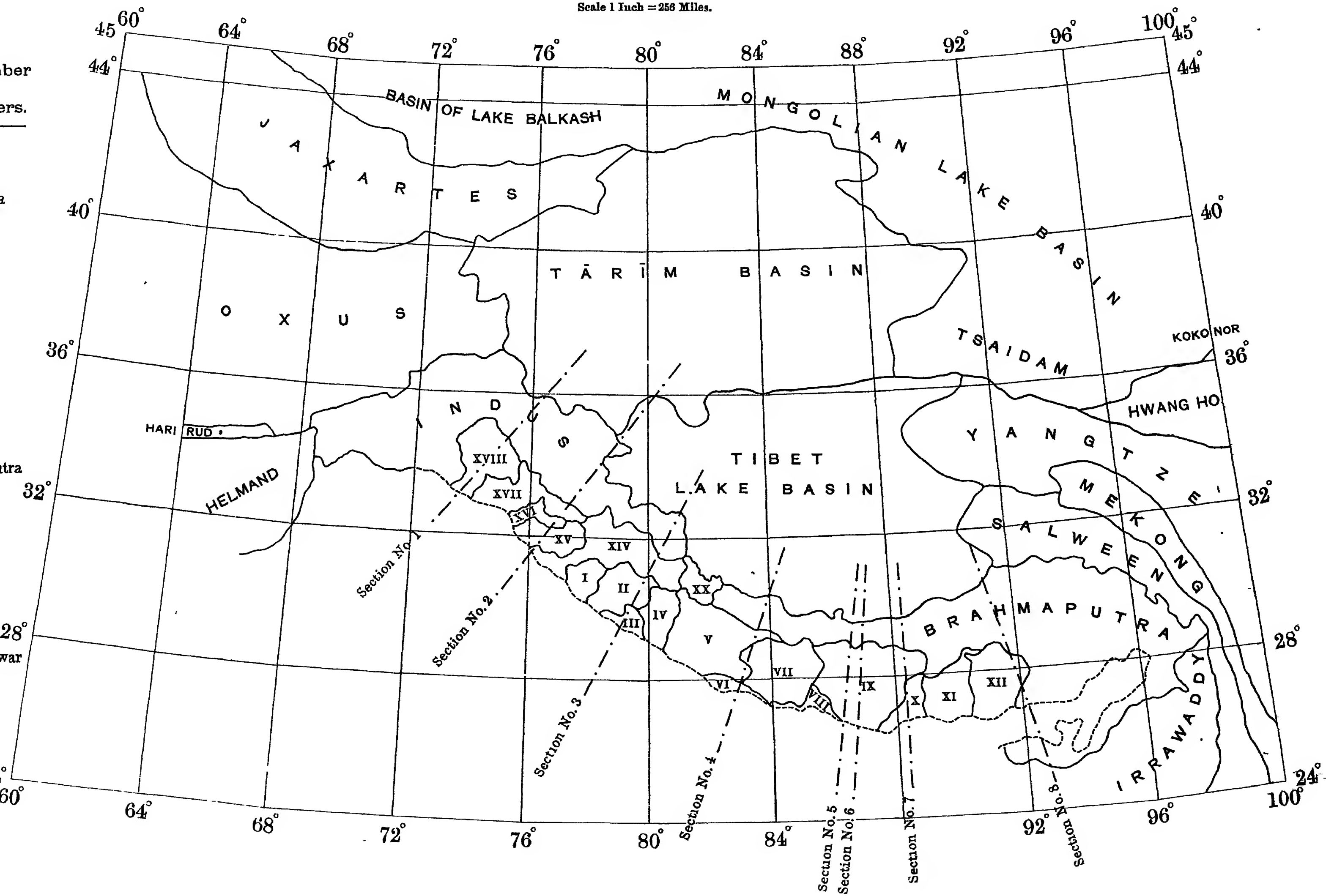
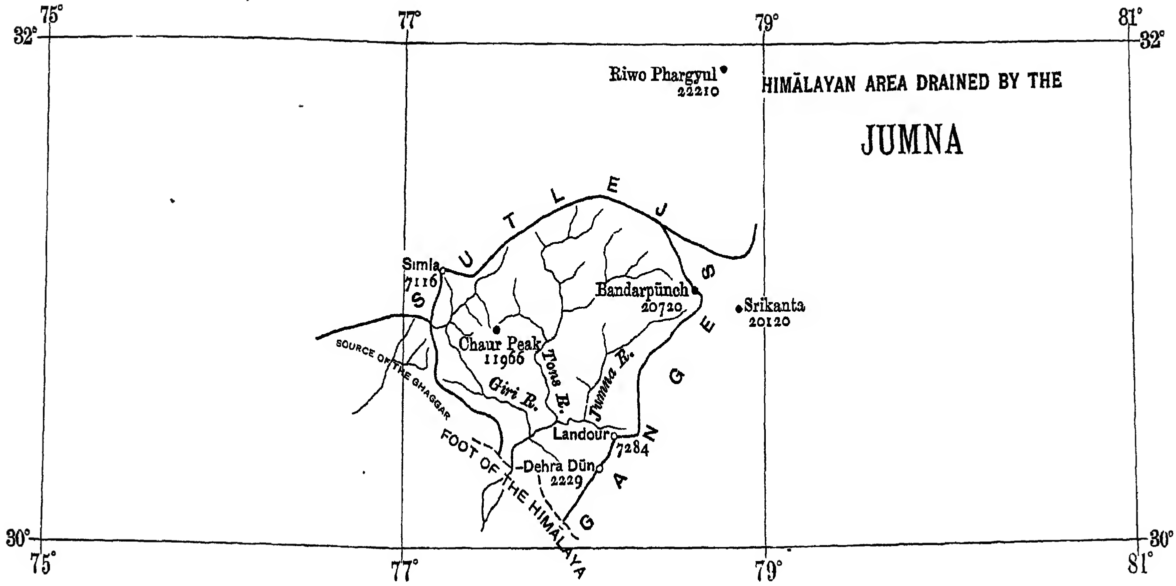
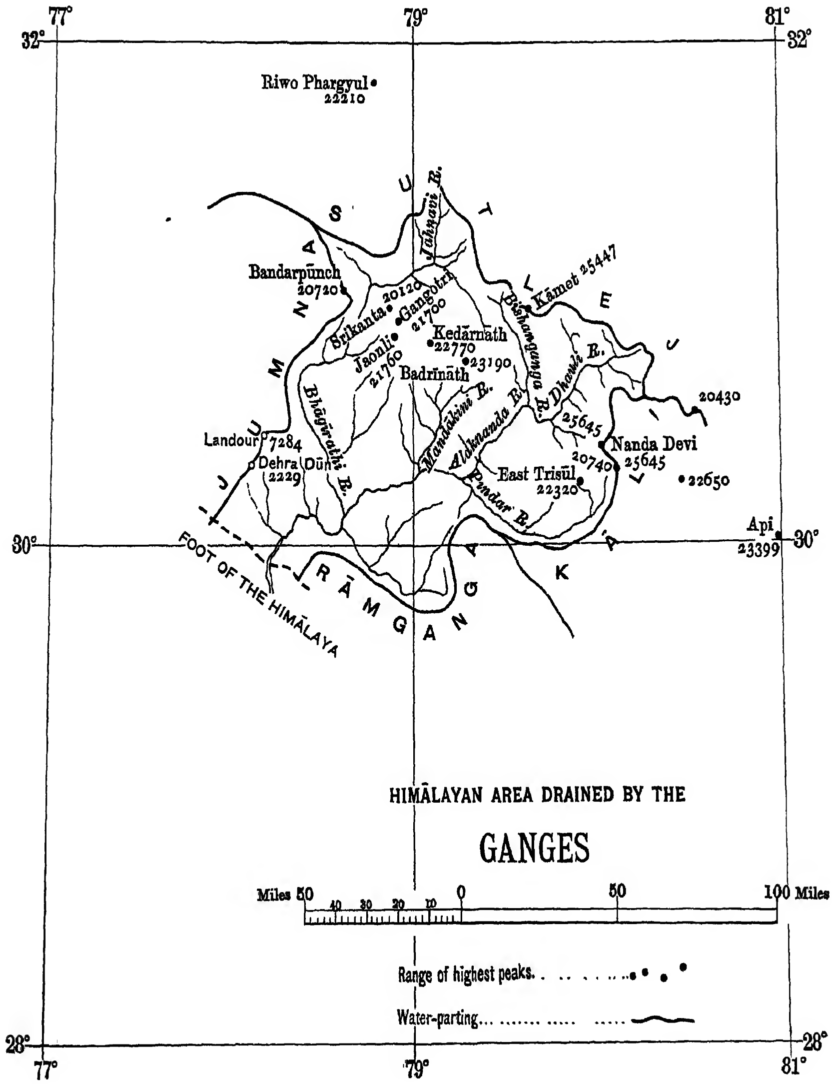
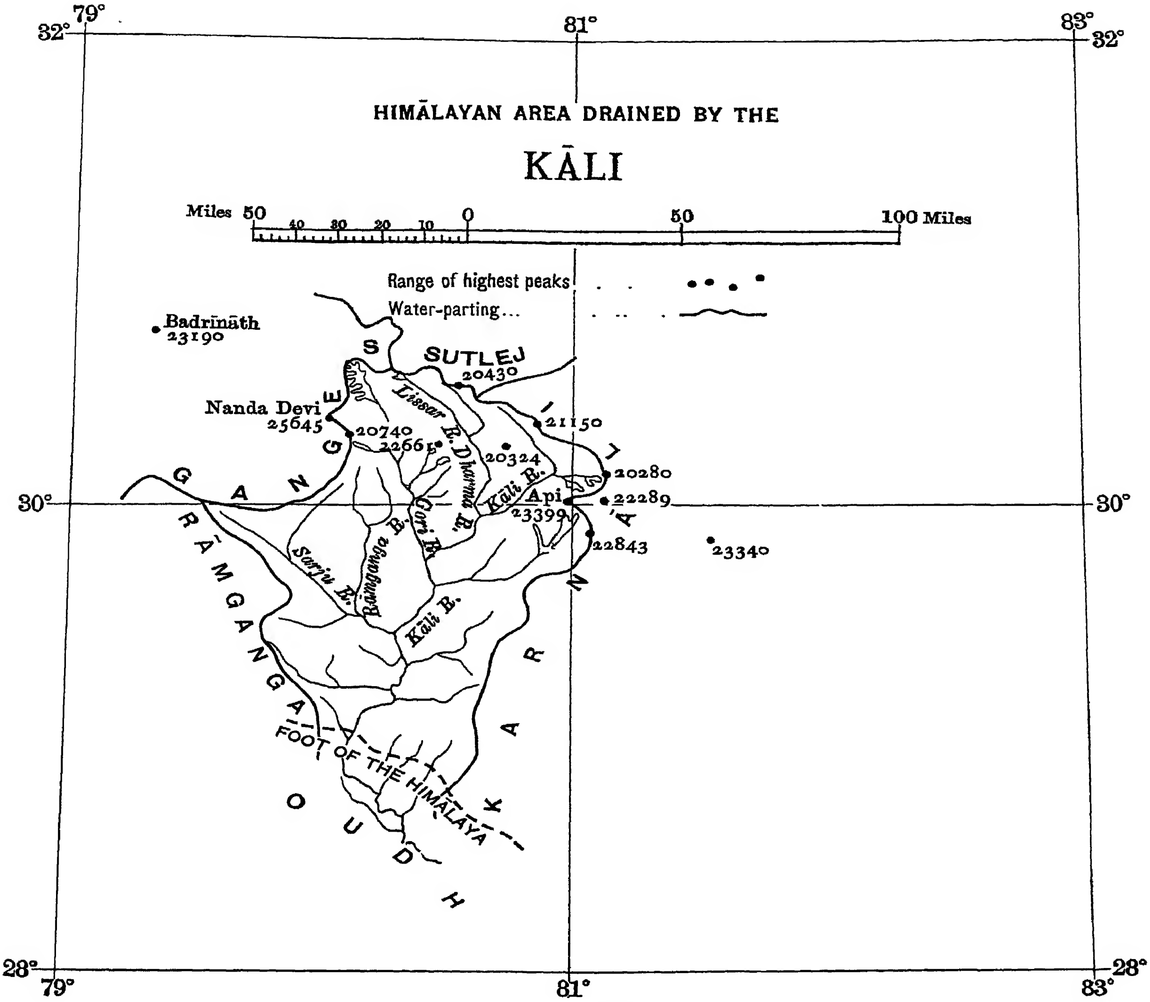
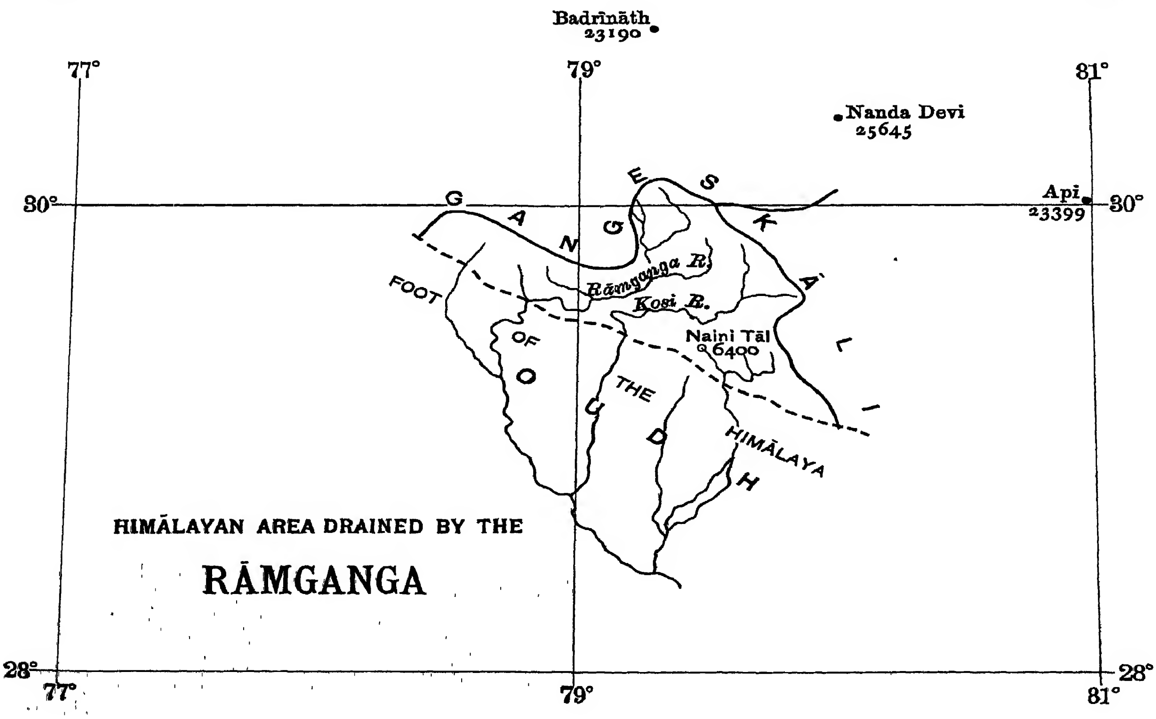


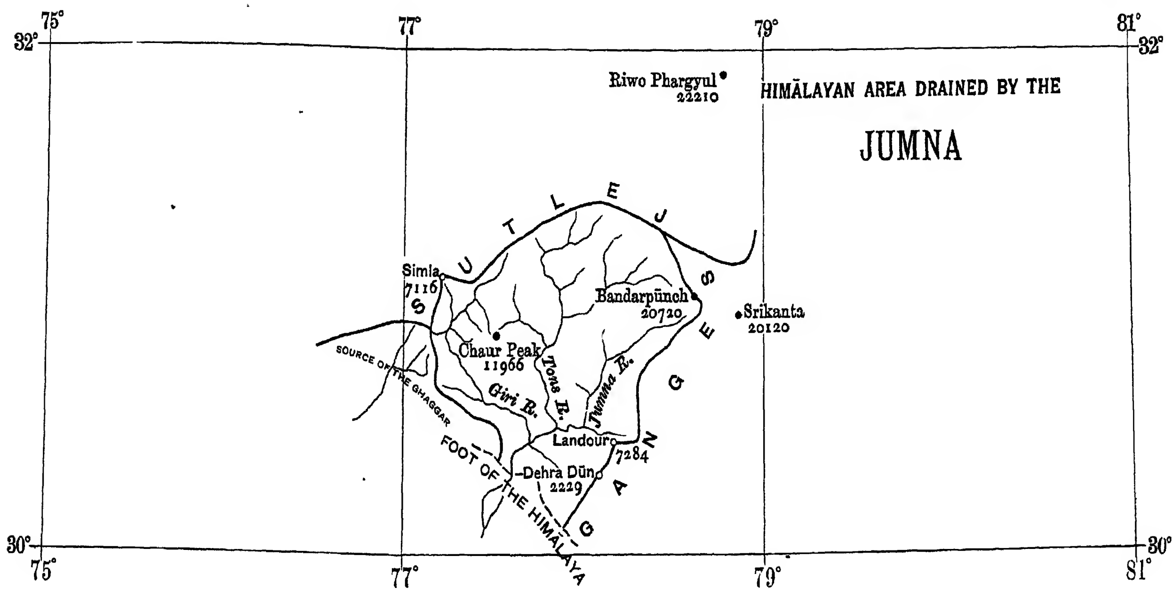
CHART XXIV


HIMĀLAYAN AREA DRAINED BY THE
JUMNA
75°
77°
79°
81°
32°
30°
Riwo Phargyul 22210
Simla 7116
Bandarpūnch 20720
Srikanta 20120
Chaur Peak 11966
Tons R.
Jumna R.
Giri R.
Landour 7284
Dehra Dūn 2229
SOURCE OF THE GHAGGAR
FOOT OF THE HIMĀLAYA
SUTLEJ
GANGES


77°
79°
81°
32°
30°
28°
Riwo Phargyul 22210
Bandarpūnch 20720
Srikanta 20120
Gangotri 21700
Jaonli 21760
Kedārnath 22770
23190
Badrīnāth
Kāmet 25447
Jahnavi R.
Bhāgīrathi R.
Mandākini R.
Alaknanda R.
Bishanganga R.
Dhauli R.
Pindar R.
20430
25645
Nanda Devi 25645
20740
East Trisūl 22320
22650
Gurla Mandhāta 25355
Api 23399
Landour 7284
Dehra Dūn 2229
FOOT OF THE HIMĀLAYA
SUTLEJ
JUMNA
KĀLI
RĀMGANGA
HIMĀLAYAN AREA DRAINED BY THE
GANGES
Miles 50 40 30 20 10 0 50 100 Miles
Range of highest peaks
Water-parting


HIMĀLAYAN AREA DRAINED BY THE
KĀLI
Miles 50 40 30 20 10 0 50 100 Miles
Range of highest peaks
Water-parting...
Badrīnāth 23190
Nanda Devi 25645
SUTLEJ
20430
21150
20740
22661
20324
20280
Api 23399
22289
22843
23340
Lissar R.
Dharma R.
Kali R.
Gori R.
Ramganga R.
Sarju R.
Kali R.
GANGES
RĀMGANGA
KARNĀLI
FOOT OF THE HIMĀLAYA
OUDH
32°
30°
28°
79°
81°
83°


Badrīnāth 23190
Nanda Devi 25645
Api 23399
GANGES
KĀLI
Rāmganga R.
Kosi R.
Naini Tāl 6400
FOOT OF THE HIMĀLAYA
OUDH
HIMĀLAYAN AREA DRAINED BY THE
RĀMGANGA
77°
79°
81°
30°
28°


HIMĀLAYAN AREA DRAINED BY THE
JUMNA
75°
77°
79°
81°
32°
30°
Riwo Phargyul 22210
SUTLEJ
Simla 7116
Bandarpūnch 20720
Srikanta 20120
Chaur Peak 11966
Tons R.
Jumna R.
Giri R.
SOURCE OF THE GHAGGAR
GANGES
Landour 7284
Dehra Dūn 2229
FOOT OF THE HIMALAYA

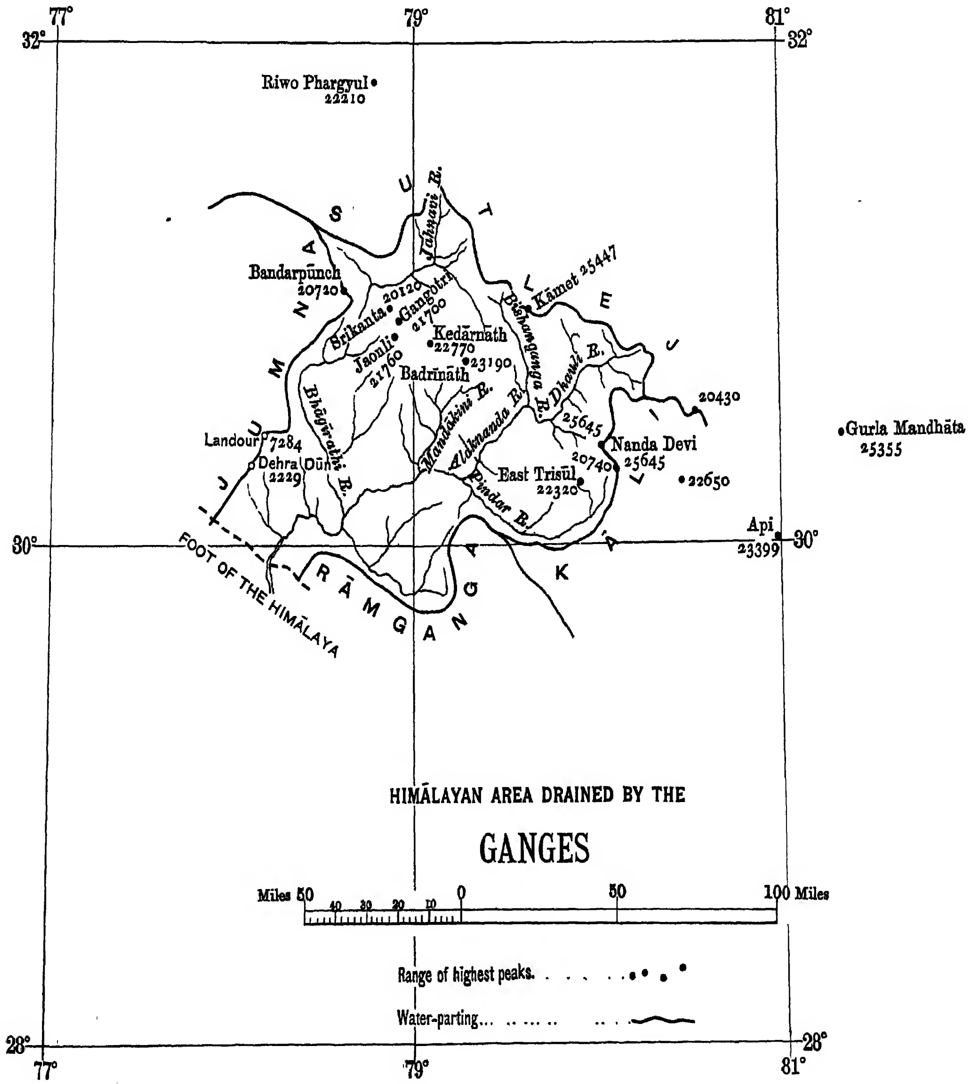
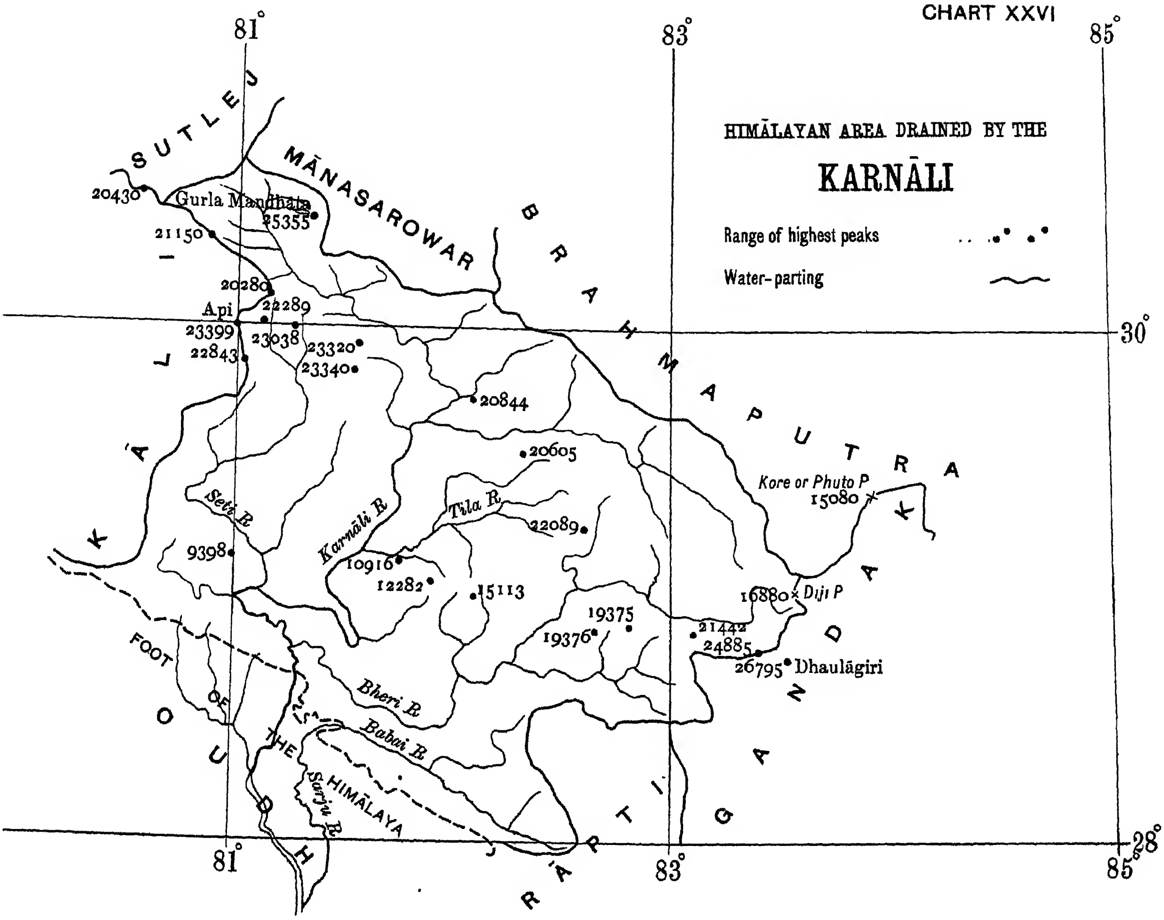

77°
79°
81°
32°
30°
28°
Riwo Phargyul 22210
SUTLEJ
Jahnavi R.
Kāmet 25447
Bandarpūnch 20720
Srikanta 20120
Gangotri 21700
Jaonli 21760
Kedārnath 22770
23190
Badrīnāth
Bishanganga R.
Dhauli R.
20430
Gurla Mandhāta 25355
JUMNA
Bhāgīrathi R.
Mandākini R.
Alaknanda R.
25645
Nanda Devi 25645
20740
East Trisūl 22320
22650
Pindar R.
Landour 7284
Dehra Dūn 2229
KALI
Api 23399
FOOT OF THE HIMĀLAYA
RĀMGANGA
HIMĀLAYAN AREA DRAINED BY THE
GANGES
Miles 50 40 30 20 10 0 50 100 Miles
Range of highest peaks.
Water-parting...

CHART XXVI


HIMĀLAYAN AREA DRAINED BY THE
KARNĀLI
Range of highest peaks
Water-parting
SUTLEJ
MĀNASAROWAR
BRAHMAPUTRA
KĀLI
GANDAK
RĀPTI
OUDH
FOOT OF THE HIMĀLAYA
Gurla Mandhata
Api
Dhaulāgiri
Kore or Phuto P
Diji P
Seti R.
Karnāli R.
Tila R.
Bheri R.
Babai R.
Sarju R.
20430
21150
25355
20280
22289
23399
23038
22843
23320
23340
20844
20605
22089
15080
9398
10916
12282
15113
19375
19376
16880
21442
24885
26795
81°
83°
85°
30°
28°

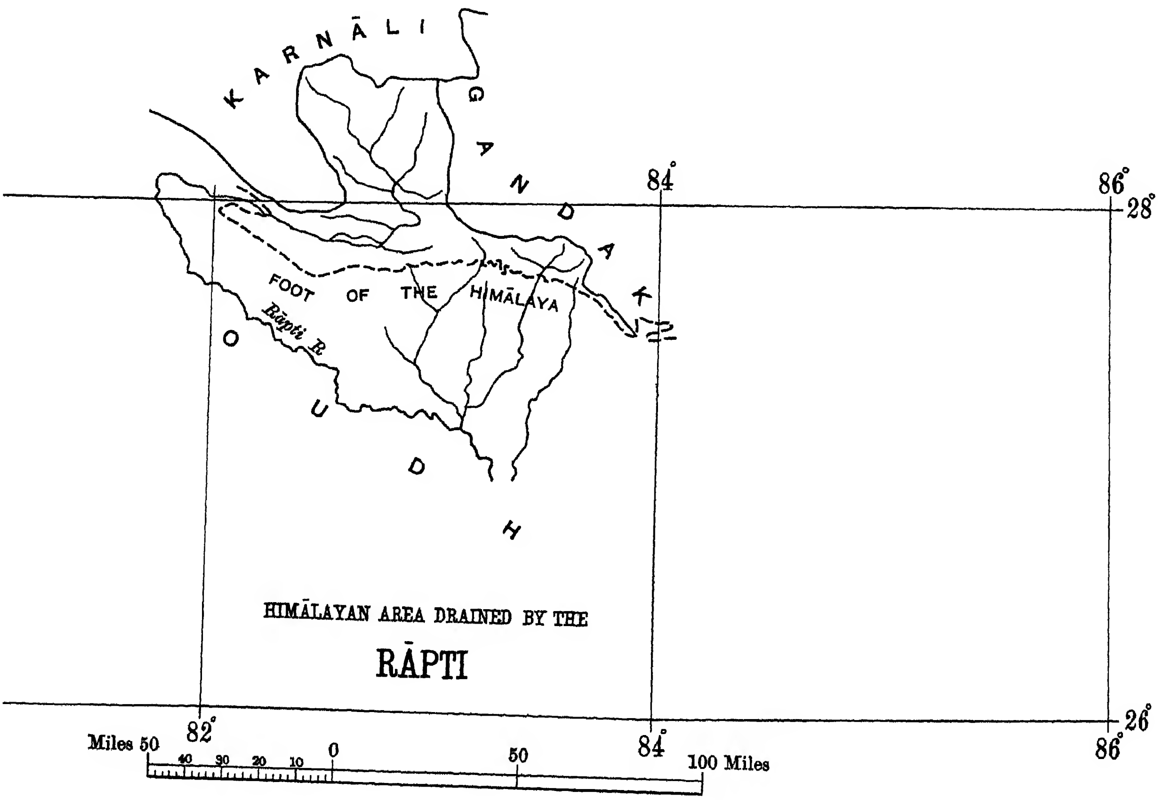
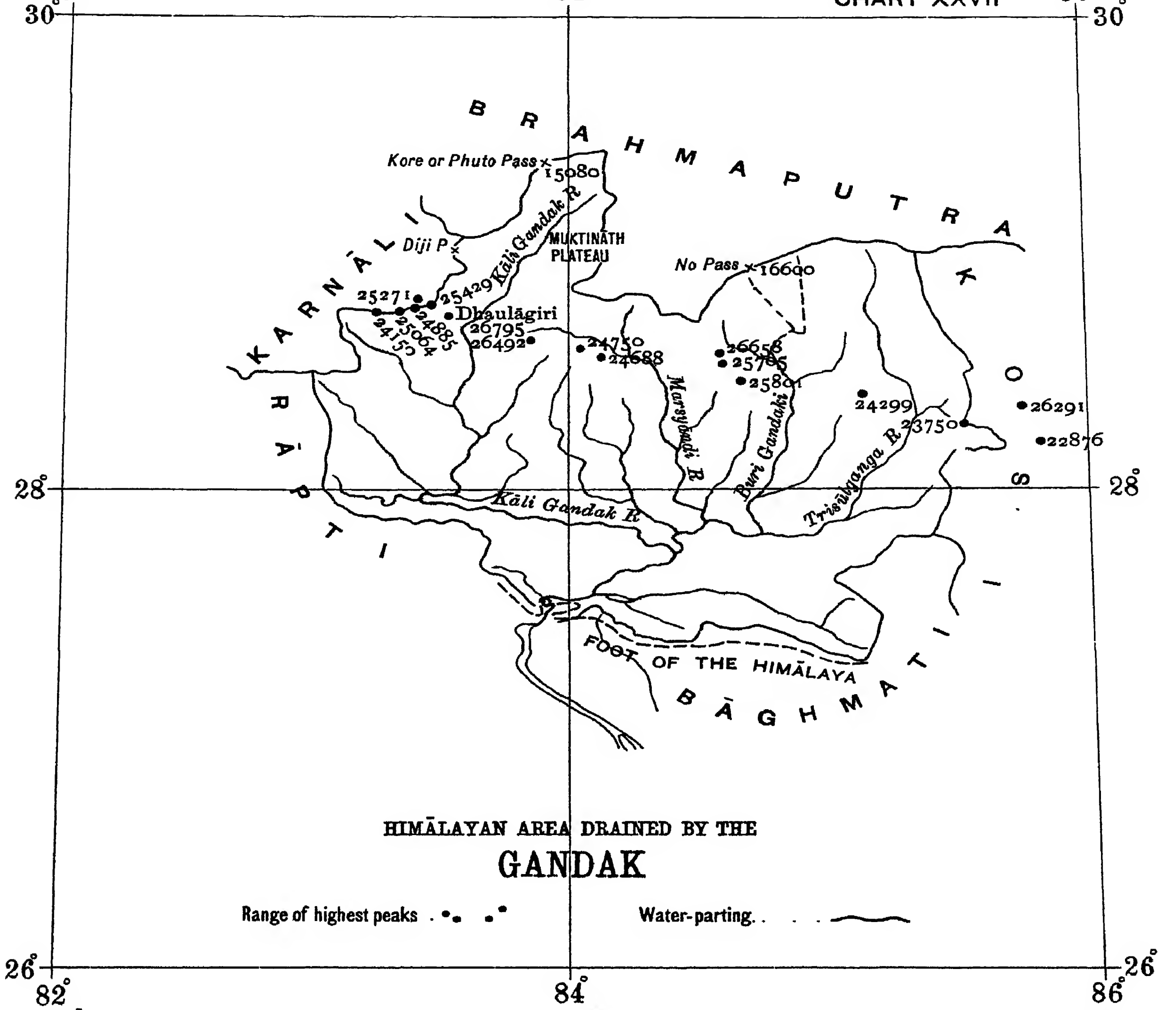
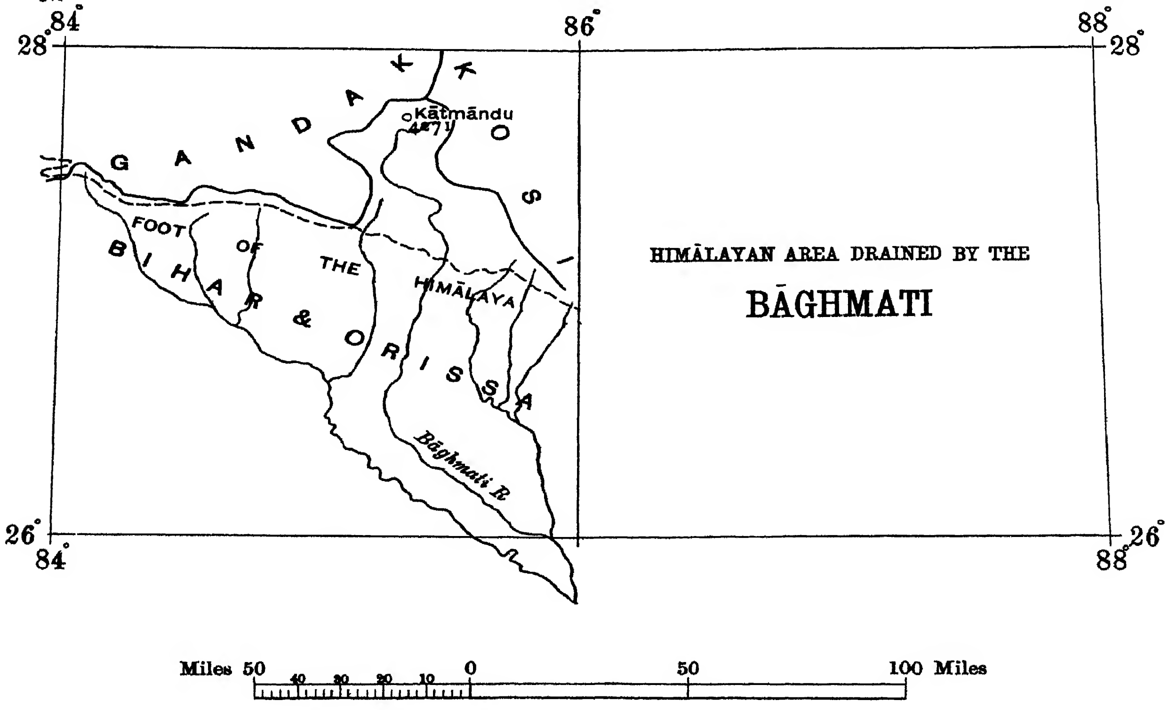

KARNĀLI
GANDAK
FOOT OF THE HIMĀLAYA
Rāpti R.
OUDH
HIMĀLAYAN AREA DRAINED BY THE
RĀPTI
82°
84°
86°
28°
26°
Miles 50
40
30
20
10
0
50
100 Miles

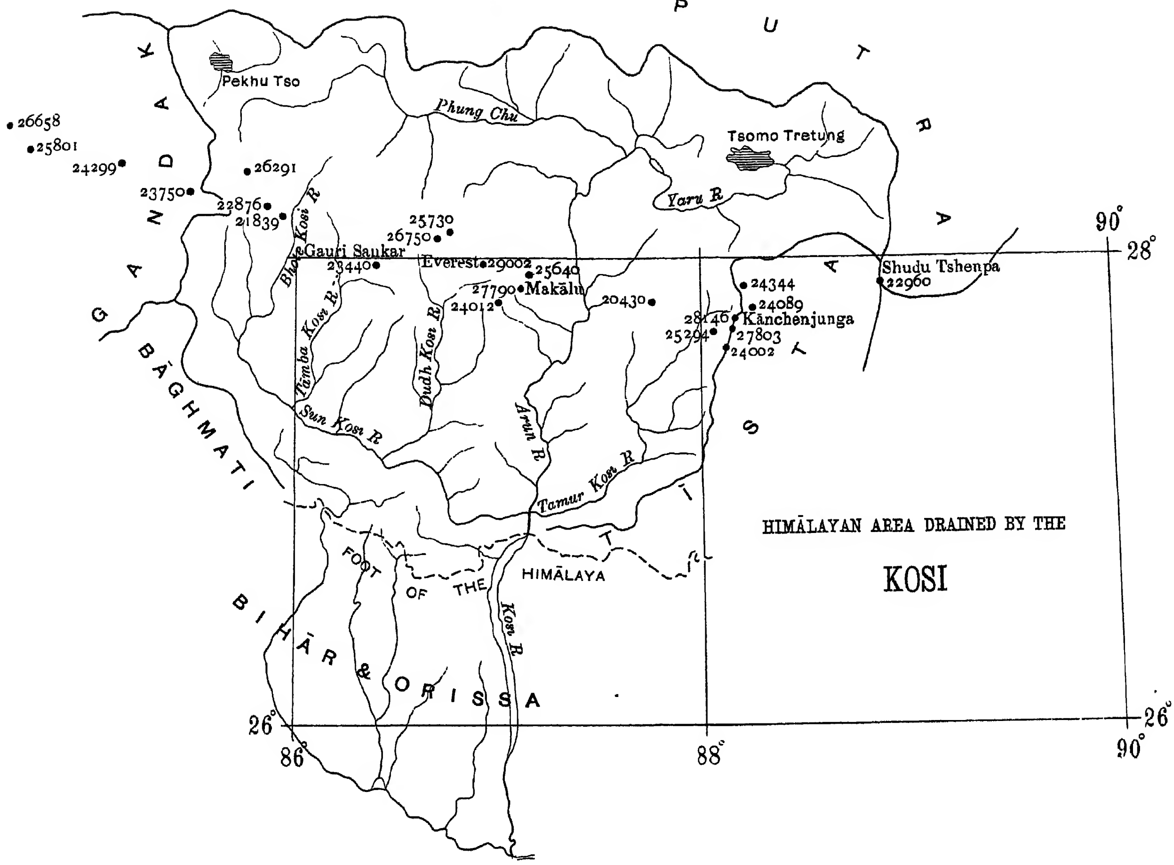
CHART XXVII

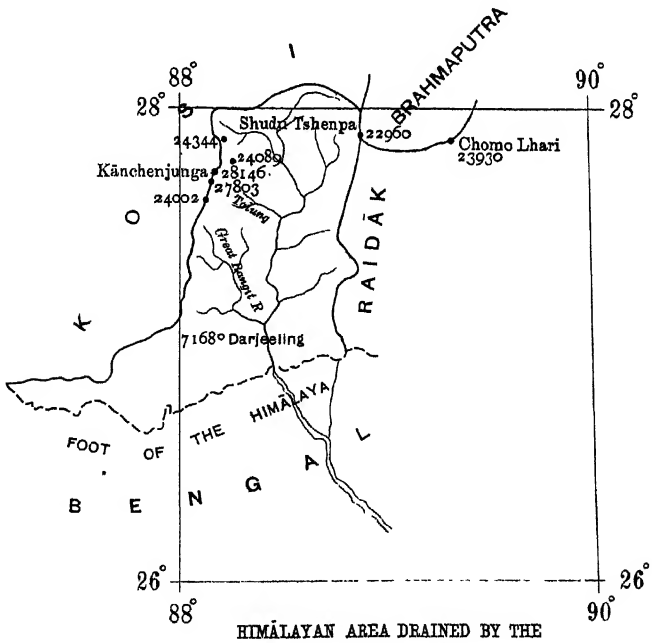


BRAHMAPUTRA
KOSI
KARNĀLI
RĀPTI
BĀGHMATI
Kore or Phuto Pass
15080
Kāli Gandak R
Diji P
MUKTINĀTH PLATEAU
No Pass
16600
25271
25429
Dhaulāgiri
26795
24885
25064
24150
26492
24750
24688
26658
25705
25801
24299
26291
23750
22876
Marsyāndi R
Buri Gandaki
Trisūlganga R
Kāli Gandak R
FOOT OF THE HIMĀLAYA
HIMĀLAYAN AREA DRAINED BY THE
GANDAK
Range of highest peaks
Water-parting



GANDAK
KOSI
Kātmāndu
4471
FOOT OF THE HIMĀLAYA
BIHAR & ORISSA
Bāghmati R
HIMĀLAYAN AREA DRAINED BY THE
BĀGHMATI
Miles 50 40 30 20 10 0 50 100 Miles





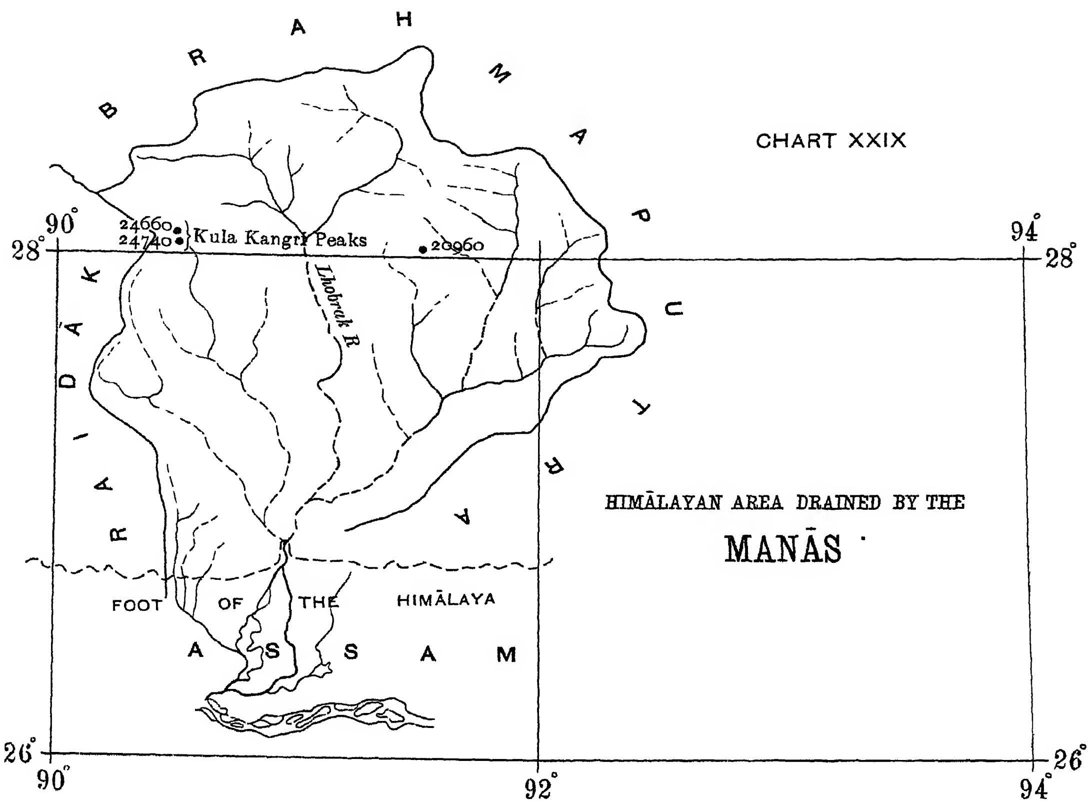
HIMĀLAYAN AREA DRAINED BY THE

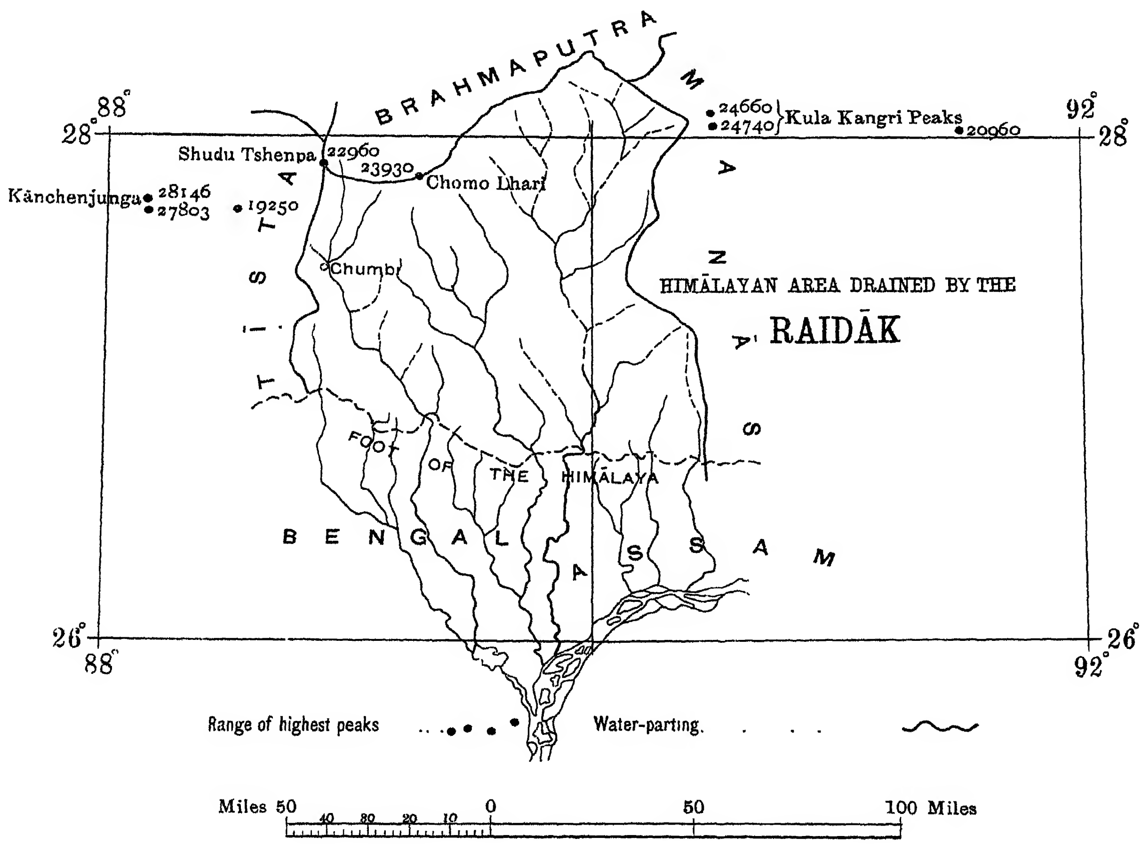
TĪSTA

Miles 50 40 30 20 10 0 50 100 Miles

Range of highest peaks . . . Water-parting . . .

CHART XXIX


BRAHMAPUTRA
RAIDĀK
24660
24740
Kula Kangri Peaks
20960
Lhobrak R.
HIMĀLAYAN AREA DRAINED BY THE
MANĀS
FOOT OF THE HIMĀLAYA
ASSAM
90°
92°
94°
28°
26°


BRAHMAPUTRA
MANĀS
TĪSTA
24660
24740
Kula Kangri Peaks
20960
Shudu Tshenpa
22960
23930
Chomo Lhari
Kānchenjunga
28146
27803
19250
Chumbi
HIMĀLAYAN AREA DRAINED BY THE
RAIDĀK
FOOT OF THE HIMĀLAYA
BENGAL
ASSAM
88°
92°
28°
26°
Range of highest peaks
Water-parting.
Miles 50 40 30 20 10 0 50 100 Miles

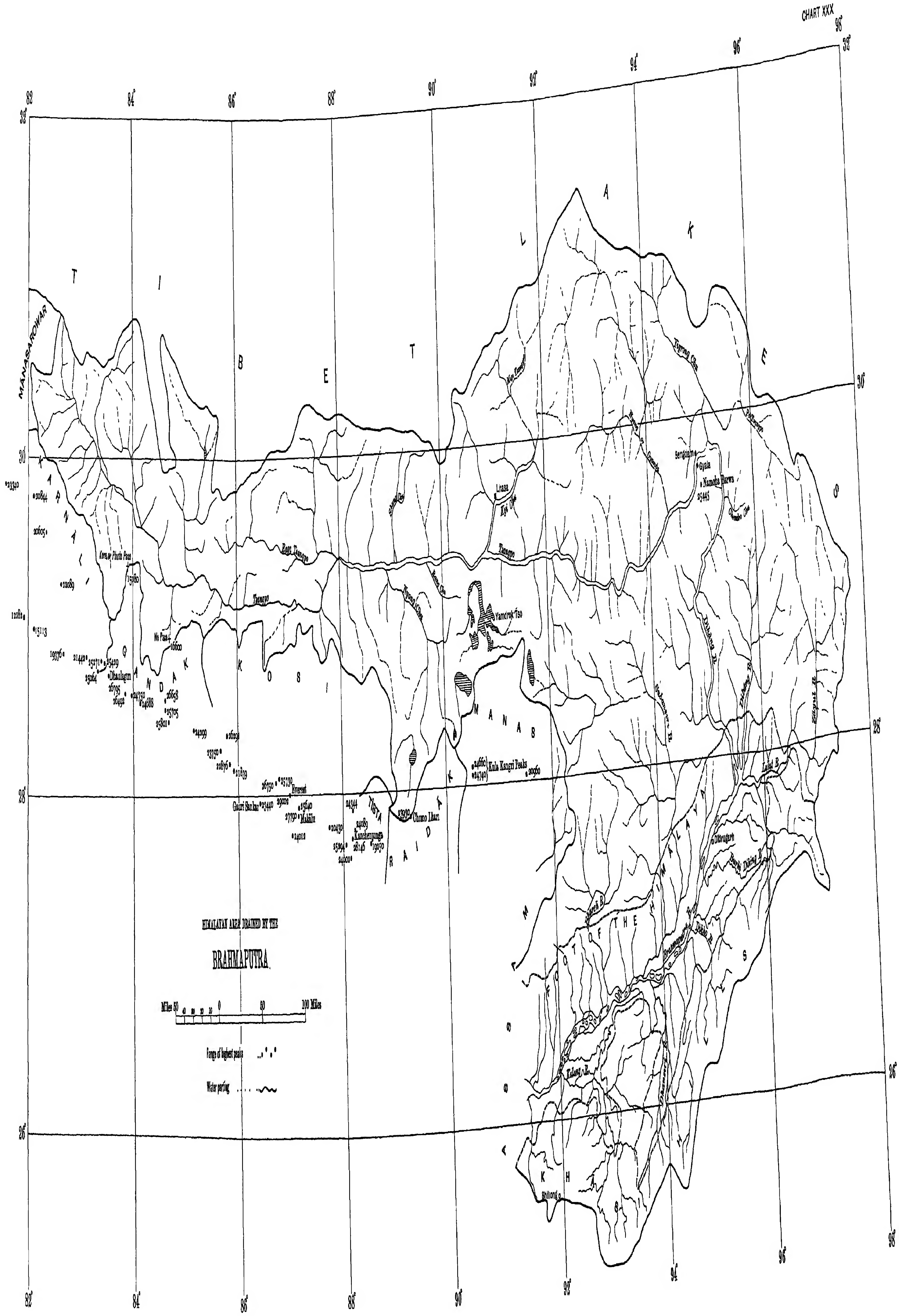
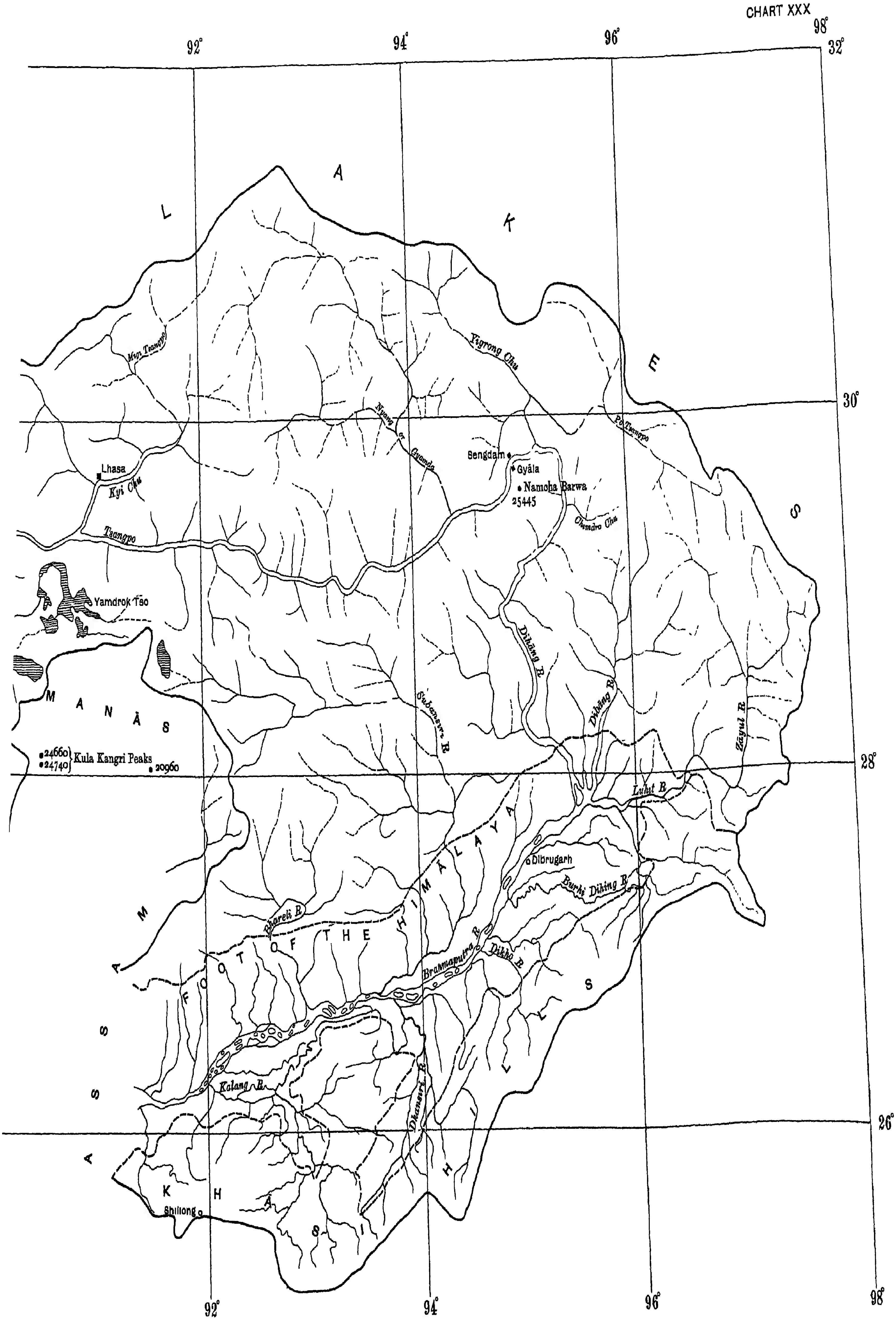


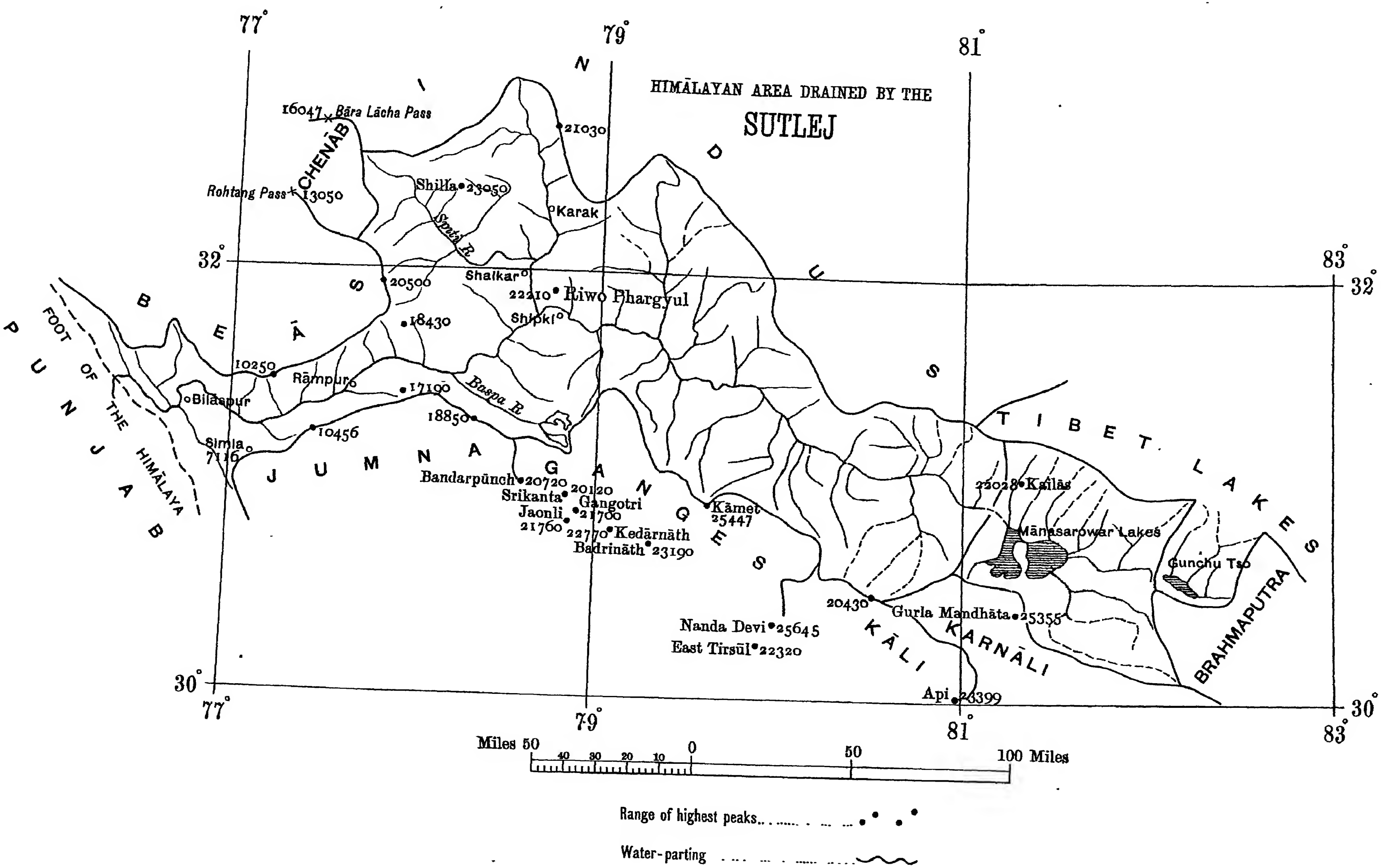
CHART XXX
HIMALAYAN AREA DRAINED BY THE
BRAHMAPUTRA.
Miles 50 40 30 20 10 0 50 100 Miles
Range of highest peaks
Water parting
MANASAROWAR
T I B E T
L A K E S
KARNALI
GANDAK
KOSI
TISTA
RAIDAK
MANAS
Tsangpo
Kongyu Phutu Pass
No Pass
Dhaulagiri
Everest
Gauri Sankar
Makalu
Kanchenjunga
Chomo Lhari
Kula Kangri Peaks
Yamdrok Tso
Lhasa
Kyi Chu
Gyala
Namcha Barwa
Dibang R.
Lohit R.
Dibrugarh
Shillong
FOOT OF THE HIMALAYA
Brahmaputra
Kalang R.
K H A S I
82° 84° 86° 88° 90° 92° 94° 96° 98°
32° 30° 28° 26°

CHART XXX

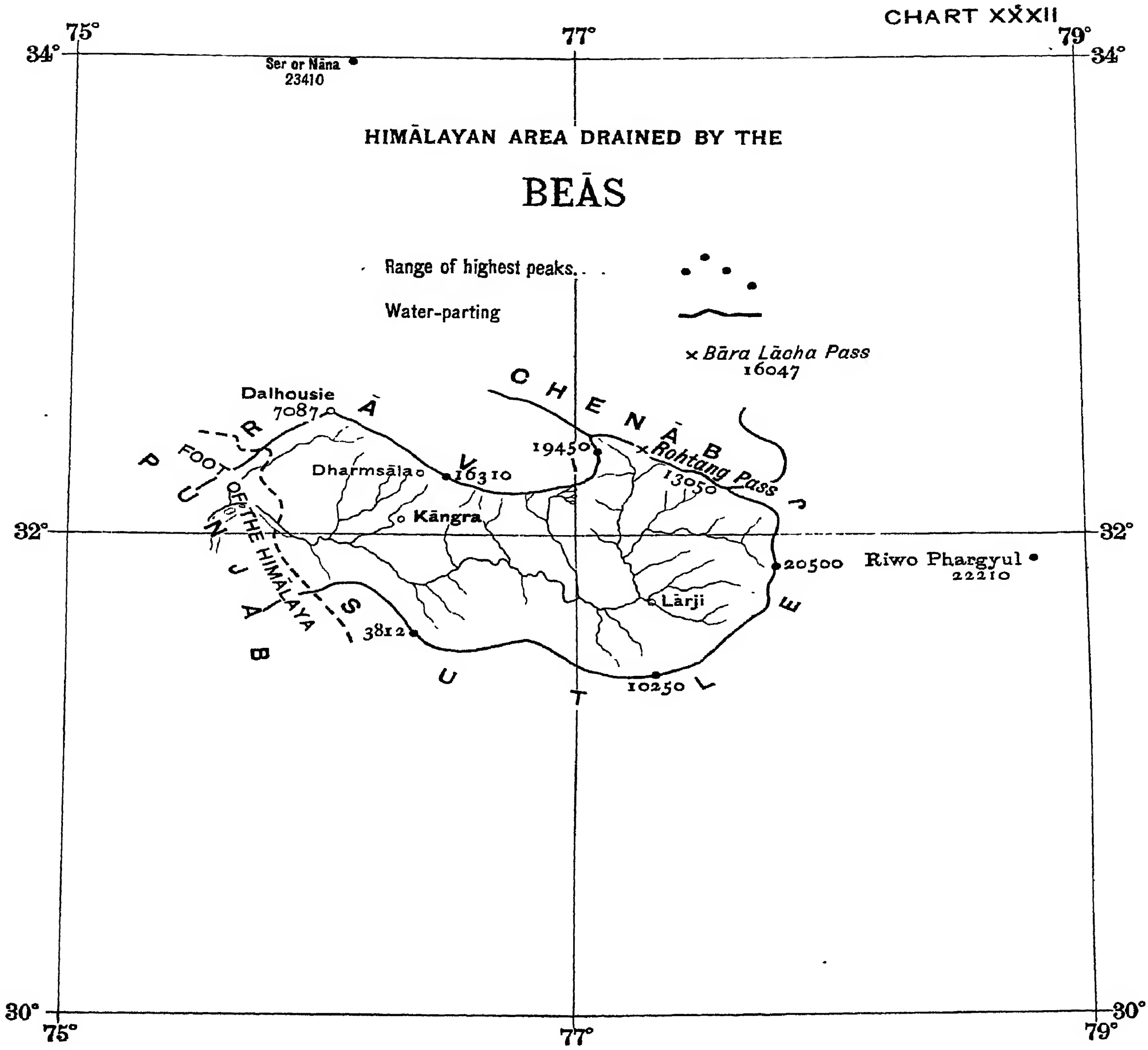


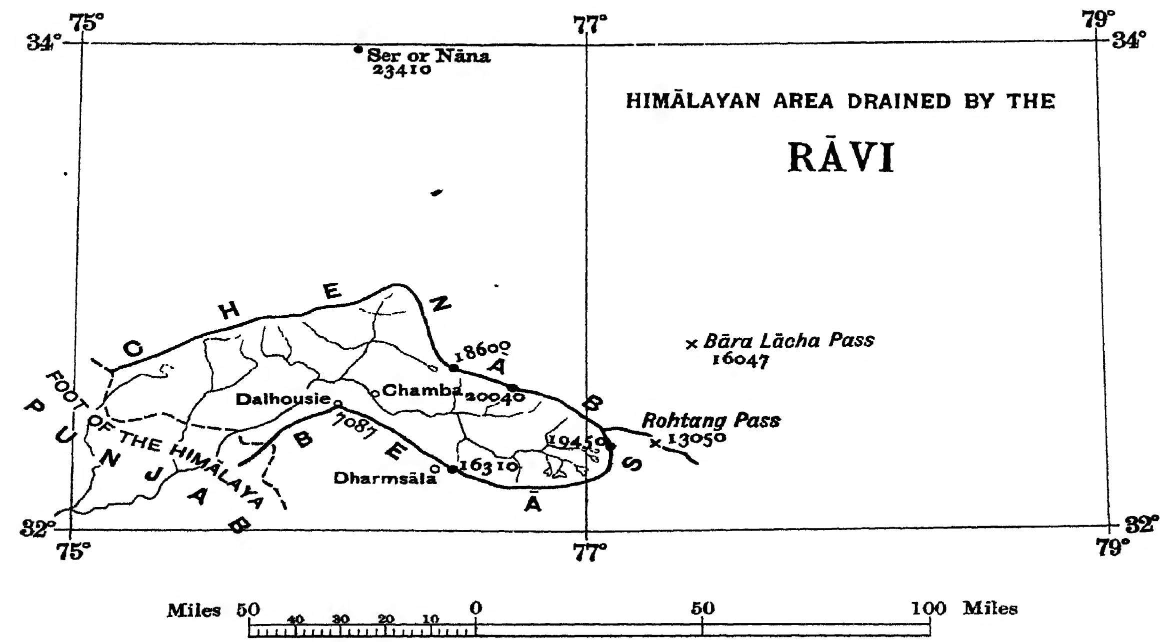
98°
32°
92°
94°
96°
30°
28°
26°
L
A
K
E
S
Mugu Tsangpo
Yigrong Chu
Nyang or Gyamda
Po Tsangpo
Lhasa
Kyi Chu
Tsangpo
Sengdam
Gyâla
Namcha Barwa
25445
Chimdro Chu
Yamdrok Tso
Dihâng R.
Dibâng R.
Zayul R.
Subansiri R.
M
A
N
Â
S
24660
24740
Kula Kangri Peaks
20960
Lohit R.
Dibrugarh
Burhi Dihing R.
F
O
O
T
O
F
T
H
E
H
I
M
Â
L
A
Y
A
Bhareli R.
Brahmaputra R.
Dikho R.
Kalang R.
Dhansiri R.
A
S
S
A
M
H
I
L
L
S
K
H
Â
S
I
Shillong

CHART XXXI



HIMĀLAYAN AREA DRAINED BY THE
SUTLEJ
INDUS
BEĀS
JUMNA
GANGES
TIBET LAKES
PUNJAB
FOOT OF THE HIMĀLAYA
CHENĀB
BRAHMAPUTRA
KĀLI
KARNĀLI
16047 Bāra Lācha Pass
Rohtang Pass 13050
Shilla 23050
Spiti R.
21030
Karak
20500
Shalkar
22210 Riwo Phargyul
Shipki
18430
10250
Rāmpur
Bilāspur
17190
Baspa R.
18850
10456
Simla 7116
Bandarpūnch 20720
20120
Srikanta
Gangotri
Jaonli 21700
21760
22770 Kedārnāth
Badrināth 23190
Kāmet 25447
Nanda Devi 25645
East Tirsūl 22320
20430
Gurla Mandhāta 25355
Api 23399
22028 Kailās
Mānasarowar Lakes
Gunchu Tso
77°
79°
81°
83°
32°
30°
Miles 50
40
30
20
10
0
50
100 Miles
Range of highest peaks
Water-parting


HIMĀLAYAN AREA DRAINED BY THE
BEĀS
Range of highest peaks
Water-parting
Ser or Nāna 23410
Bāra Lācha Pass 16047
Dalhousie 7087
Dharmsāla
16310
19450
Rohtang Pass 13050
Kāngra
20500
Riwo Phargyul 22210
Lārji
3812
10250
RĀVI
CHENĀB
SUTLEJ
PUNJAB
FOOT OF THE HIMĀLAYA
75°
77°
79°
34°
32°
30°


HIMĀLAYAN AREA DRAINED BY THE
RĀVI
Ser or Nāna 23410
Bāra Lācha Pass 16047
CHENĀB
18600
Chamba
20040
Dalhousie
7087
BEĀS
Rohtang Pass 13050
19450
Dharmsāla
16310
FOOT OF THE HIMĀLAYA
PUNJAB
75°
77°
79°
34°
32°
Miles 50 40 30 20 10 0 50 100 Miles

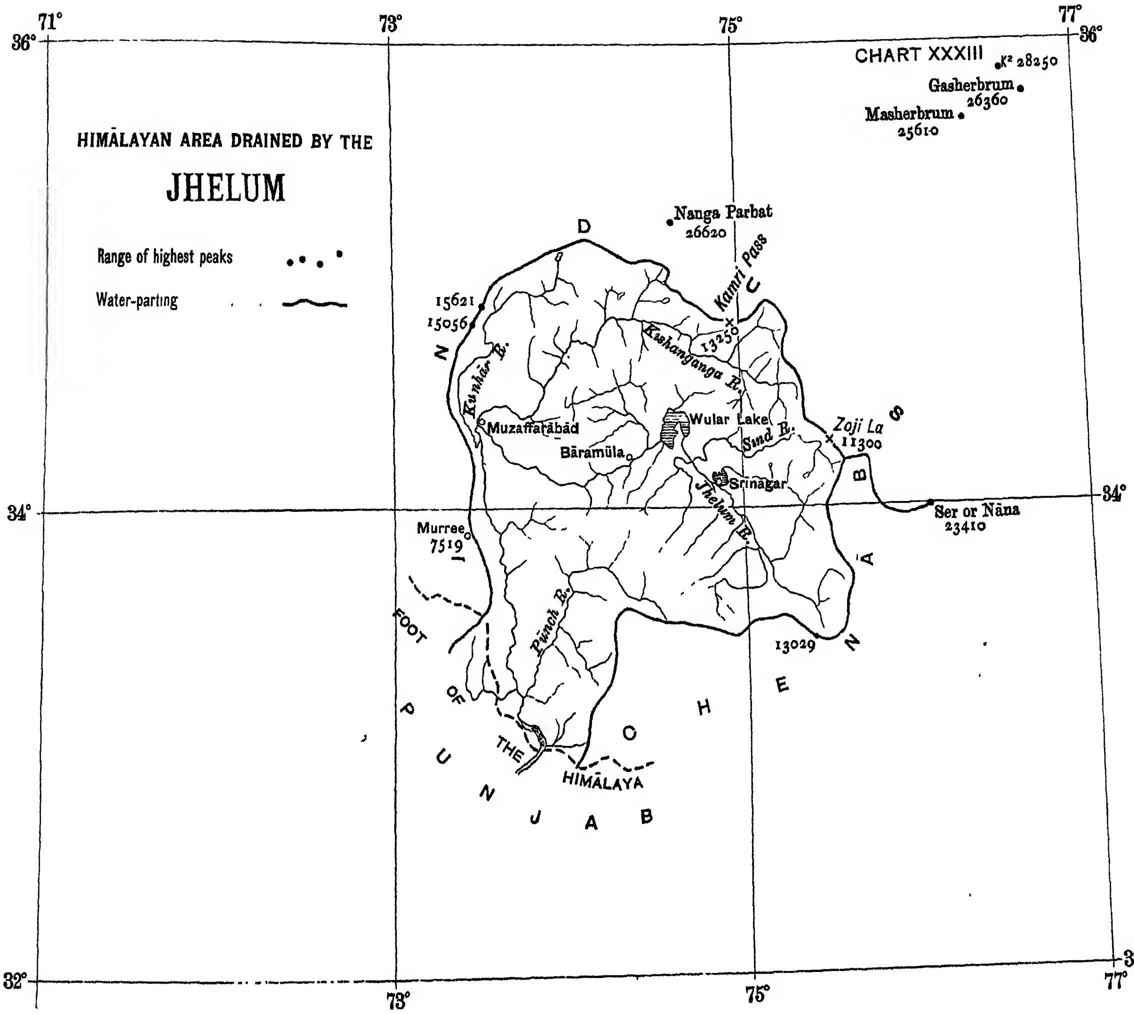
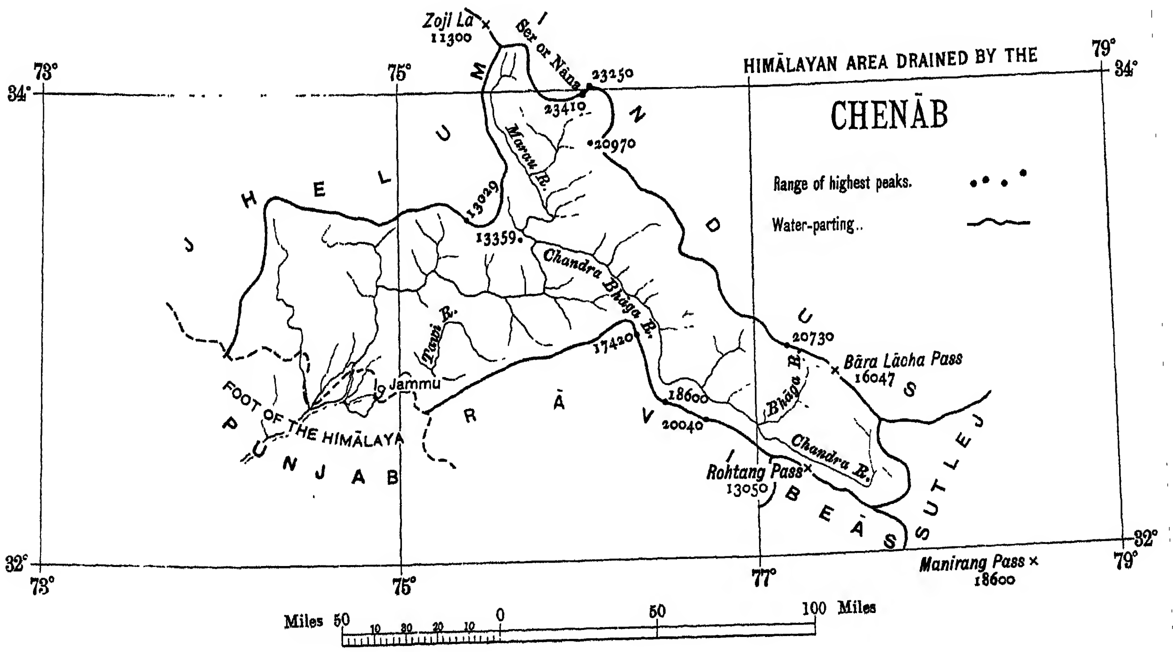
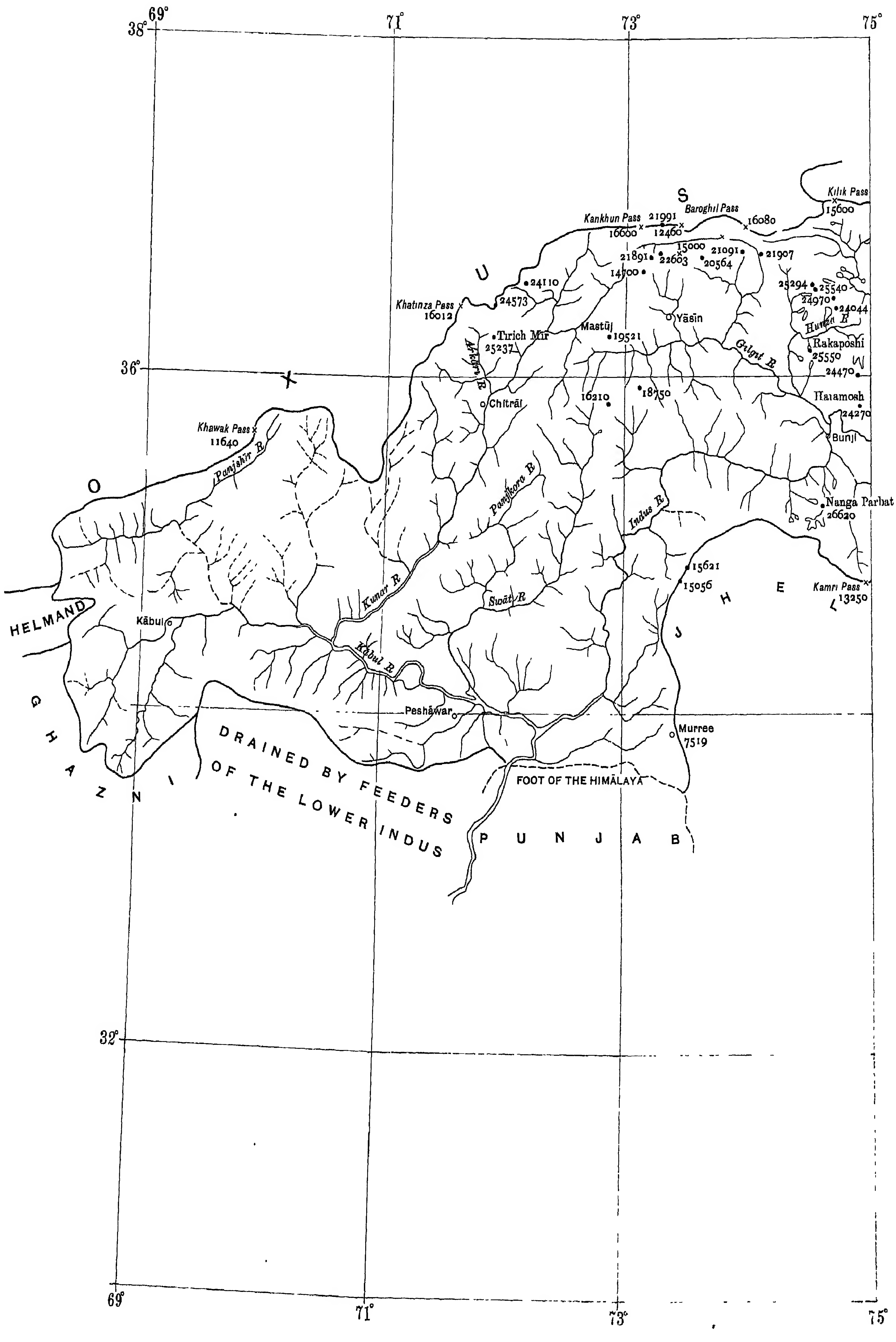


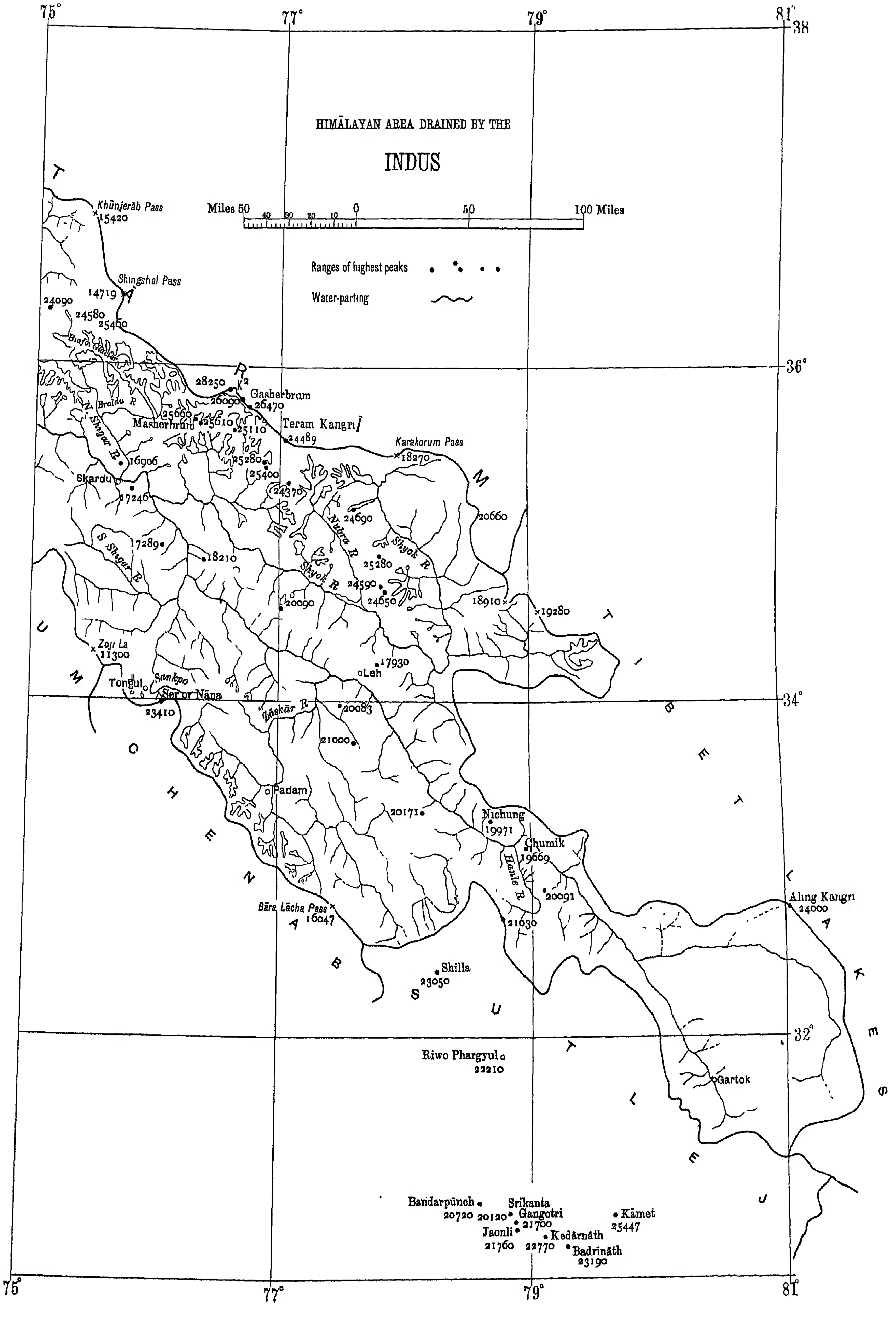
CHART XXXIII
HIMĀLAYAN AREA DRAINED BY THE
JHELUM
Range of highest peaks
Water-parting
71°
73°
75°
77°
36°
34°
32°
K² 28250
Gasherbrum 26360
Masherbrum 25610
Nanga Parbat 26620
Kamri Pass
13250
15621
15056
Kunhār R.
Kishanganga R.
Muzaffarābād
Wular Lake
Sind R.
Zoji La 11300
Bāramūla
Srinagar
Jhelum R.
Ser or Nāna 23410
Murree 7519
Pūnch R.
13029
FOOT OF THE HIMĀLAYA
P U N J A B
C H E N Ā B
I N D U S


HIMĀLAYAN AREA DRAINED BY THE
CHENĀB
Range of highest peaks.
Water-parting..
73°
75°
77°
79°
34°
32°
Zoji La 11300
Ser or Nāna
23250
23410
20970
Marau R.
13029
13359
Chandra Bhaga R.
J H E L U M
I N D U S
Tawi R.
Jammu
17420
20730
Bāra Lācha Pass 16047
18600
20040
Bhāga R.
Chandra R.
Rohtang Pass 13050
FOOT OF THE HIMĀLAYA
P U N J A B
R Ā V I
B E Ā S
S U T L E J
Manirang Pass 18600
Miles 50 10 30 20 10 0 50 100 Miles



69°
71°
73°
75°
38°
36°
32°
O X U S
Kilik Pass
15600
Kankhun Pass
16600
21991
Baroghil Pass
12460
16080
15000
21891
22663
21091
20564
21907
14700
25294
25540
24970
24044
Hunza R.
24110
24573
Khatinza Pass
16012
Tirich Mir
25237
Mastūj
19521
Yāsīn
Gilgit R.
Rakaposhi
25550
24470
Haramosh
24270
Bunji
16210
18750
Chitrāl
Khawak Pass
11640
Panjshir R.
Panjkora R.
Indus R.
Nanga Parbat
26620
15621
15056
Kamri Pass
13250
J H E L
Kunar R.
Swāt R.
HELMAND
Kābul
Kābul R.
Peshāwar
Murree
7519
G H A Z N I
DRAINED BY FEEDERS OF THE LOWER INDUS
FOOT OF THE HIMĀLAYA
P U N J A B

CHART XXXIV


HIMALAYAN AREA DRAINED BY THE
INDUS
Miles 50 40 30 20 10 0 50 100 Miles
Ranges of highest peaks
Water-parting
Khūnjerāb Pass 15420
Shingshal Pass 14719
24090
24580
25460
Biafo Glacier
Braldu R.
N. Shigar R.
28250 K2
26090
Gasherbrum 26470
25660
Masherbrum 25610
25110
Teram Kangri I
24489
Karakorum Pass 18270
16906
25280
25400
Skardu
17246
24370
24690
20660
17289
S. Shigar R.
18210
Nubra R.
Shyok R.
25280
Shyok R.
24590
24650
18910
19280
20090
Zoji La 11300
17930
Leh
Tongul
Sankpo
Ser or Nāna
23410
Zāskār R.
20083
21000
Padam
20171
Nichung 19971
Chumik 19669
Hanle R.
20091
Bāra Lācha Pass 16047
21030
Aling Kangri 24000
Shilla 23050
Riwo Phargyul 22210
Gartok
Bandarpūnch 20720
Srikanta 20120
Gangotri 21700
Jaonli 21760
Kedārnāth 22770
Badrināth 23190
Kāmet 25447
T A R M
T I B E T
U M
C H E N A B
S U T L E J
L A K E S
75° 77° 79° 81°
38° 36° 34° 32°

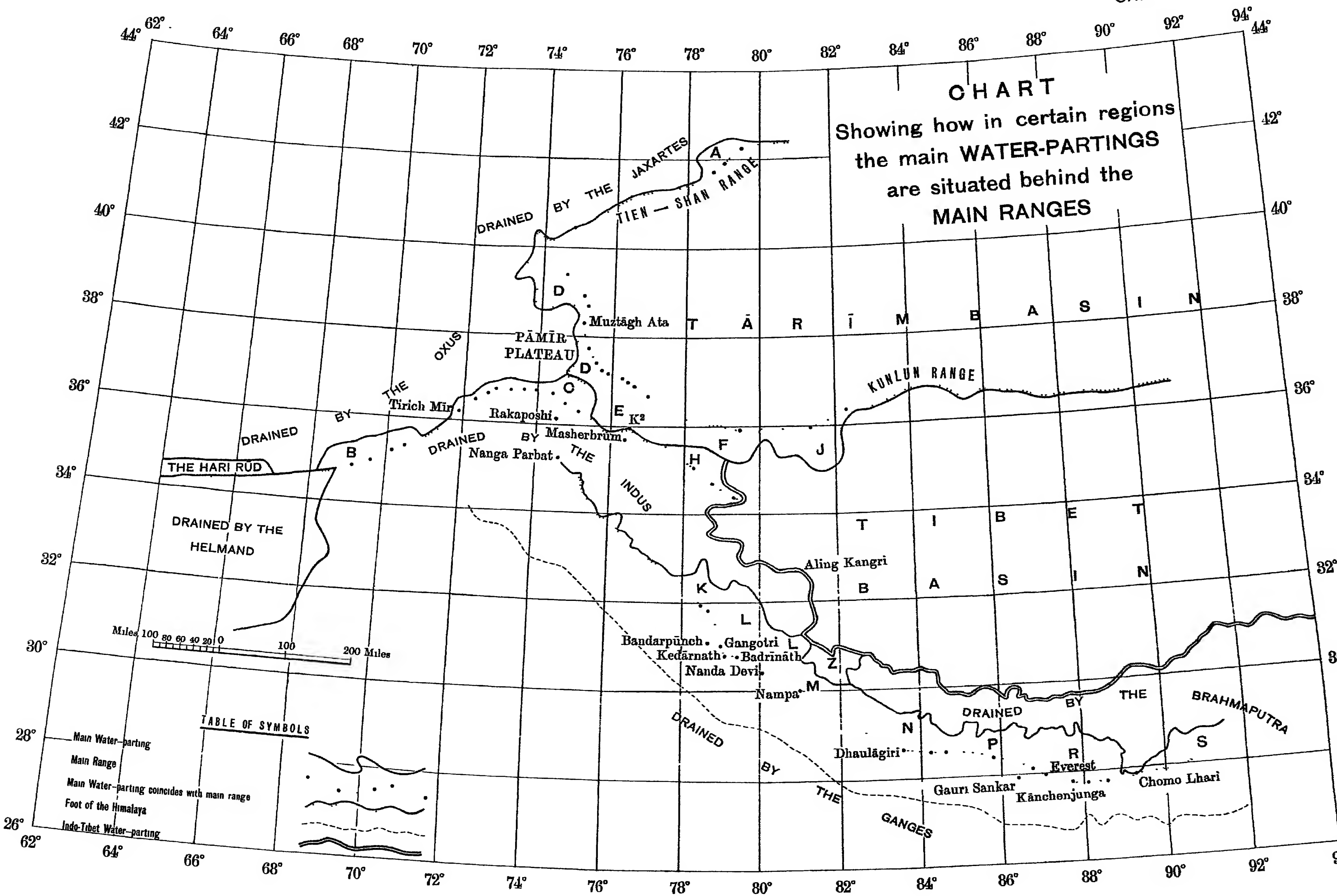


CHART
Showing how in certain regions the main WATER-PARTINGS are situated behind the MAIN RANGES
DRAINED BY THE JAXARTES
TIEN — SHAN RANGE
DRAINED BY THE OXUS
PĀMĪR PLATEAU
Muztāgh Ata
T Ā R Ī M B A S I N
KUNLUN RANGE
Tirich Mīr
Rakaposhi
Masherbrūm
K²
Nanga Parbat
DRAINED BY THE INDUS
THE HARI RŪD
DRAINED BY THE HELMAND
T I B E T
B A S I N
Aling Kangri
Bandarpūnch
Gangotri
Kedārnath
Badrīnāth
Nanda Devi
Nampa
Dhaulāgiri
Gauri Sankar
Everest
Kānchenjunga
Chomo Lhari
DRAINED BY THE BRAHMAPUTRA
DRAINED BY THE GANGES
Miles 100 80 60 40 20 0 100 200 Miles
TABLE OF SYMBOLS
Main Water-parting
Main Range
Main Water-parting coincides with main range
Foot of the Himalaya
Indo-Tibet Water-parting

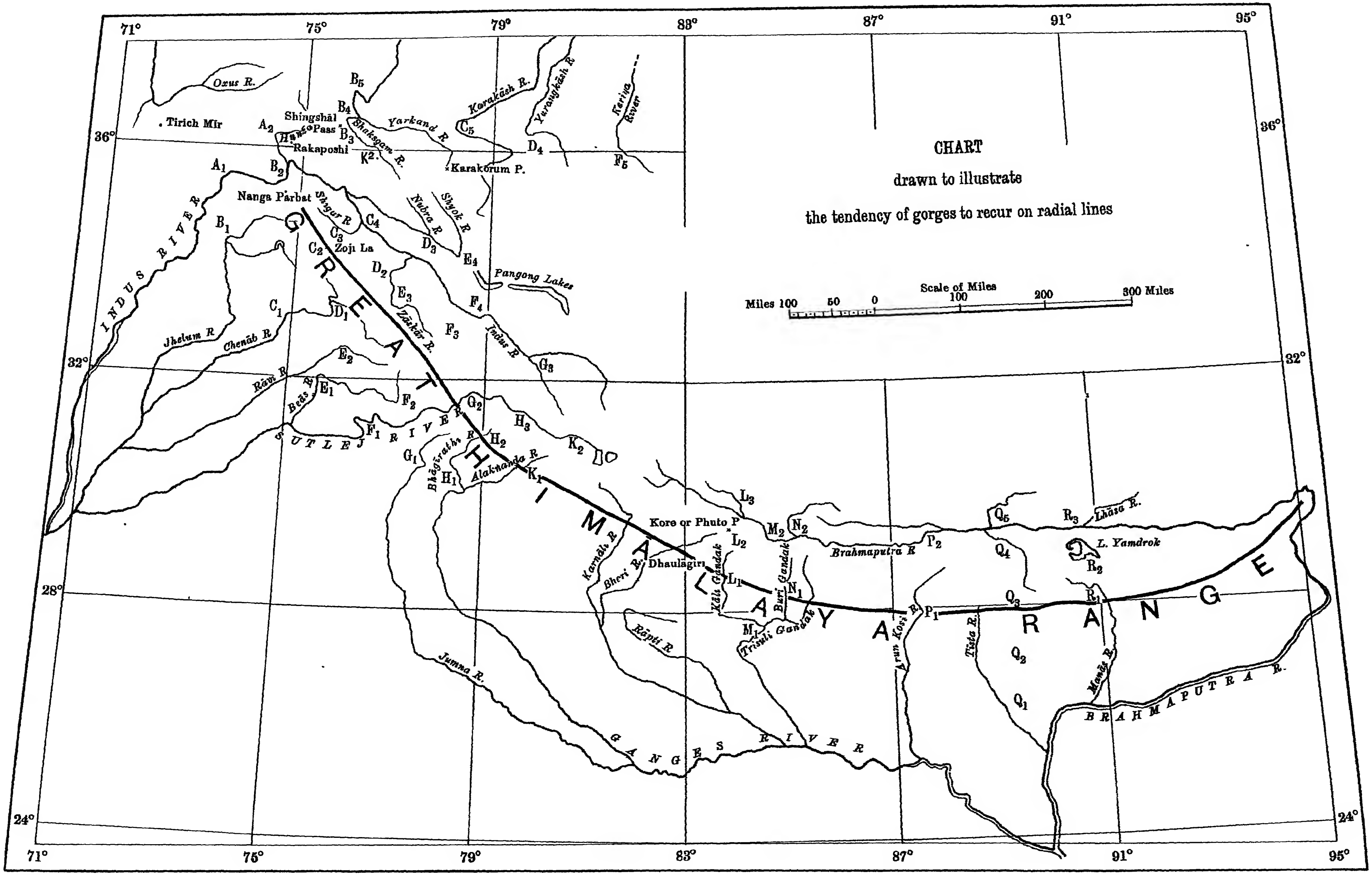


CHART
drawn to illustrate
the tendency of gorges to recur on radial lines
Scale of Miles
Miles 100 50 0 100 200 300 Miles
GREAT HIMALAYA RANGE
INDUS RIVER
SUTLEJ RIVER
GANGES RIVER
BRAHMAPUTRA R.
Oxus R.
Tirich Mir
Shingshāl
Hunza Pass
Rakaposhi
Nanga Parbat
Zoji La
Karakorum P.
Yarkand R.
Shaksgam R.
Karakāsh R.
Yurungkāsh R.
Keriya River
Shyok R.
Nubra R.
Shigar R.
Pangong Lakes
Indus R.
Zāskār R.
Jhelum R.
Chenāb R.
Rāvi R.
Beās R.
Bhāgīrathi R.
Alaknanda R.
Jumna R.
Karnāli R.
Bheri R.
Dhaulāgiri
Kore or Photo P.
Kāli Gandak
Buri Gandak
Trisuli Gandak
Rāpti R.
Brahmaputra R.
Arun Kosi R.
Tista R.
Manās R.
L. Yamdrok
Lhāsa R.

CHART XXXVII

CHART
to illustrate the varying gradients of rivers

DIAGRAM 1.
A river rising in the Great Himālayan Range

Examples: Mandākını, Tons, Setı, Indrawatı

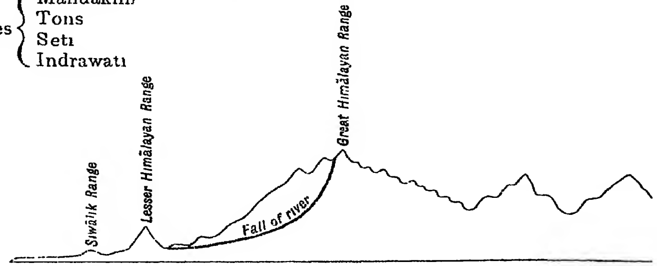


DIAGRAM 2.
A river rising slightly beyond the crest of the Great Range

Examples: Dudh Kosı, Marsyandı

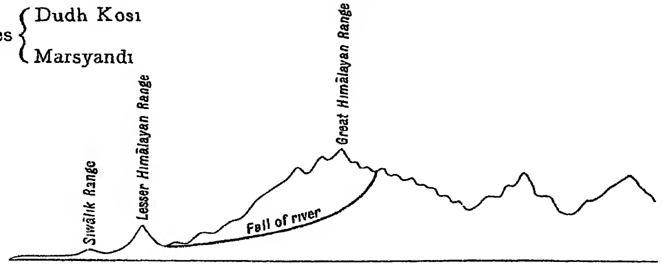


DIAGRAM 3.
A river rising considerably beyond the crest of the Great Range

Examples: Bhote Kosı, Tamba Kosı

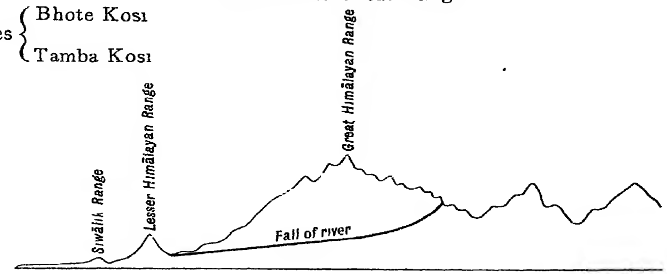


DIAGRAM 4.
A river rising in the trough behind the Great Range

Examples: Arun, Bherı, Bhāgīrathı, Karnālı

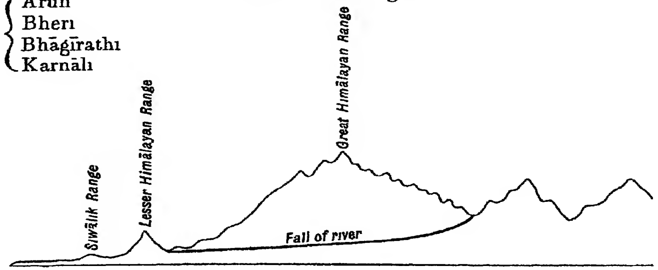
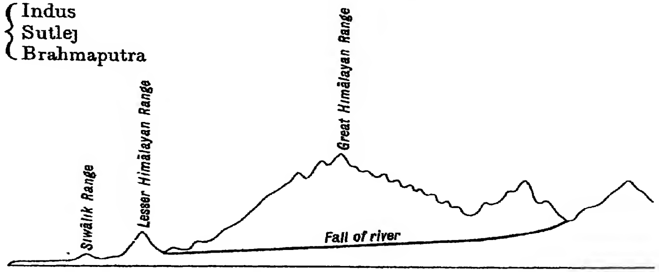


DIAGRAM 5.
A river rising in Tibet.

Examples: Indus, Sutlej, Brahmaputra



THE GEOLOGY OF THE HIMĀLAYA.

CHAPTER 30.

GEOLOGICAL SUBDIVISIONS OF THE HIMĀLAYA.

THE rocks of the Himālaya fall into three broad stratigraphical zones (Plate XXXVIII), namely—

(1) an outer or SUB-HIMĀLAYAN ZONE composed of sediments for the most part of Tertiary age ;

(2) a central or HIMĀLAYAN ZONE, comprising most of the ranges known as the Lesser Himālaya together with the line of high peaks. This is composed of granite and other crystalline rocks and a great group of unfossiliferous sediments of unknown age ; and

(3) a northern or TIBETAN ZONE, lying for the most part behind the line of high peaks (the axis of the Great Himālayan range) and composed of a series of highly fossiliferous sediments ranging in age from the Cambrian to the Tertiary epochs.

The following table shows the classification and the more important subdivisions :—

TABLE XIX.

	Sub-Himālayan Zone.	Himālayan Zone.	Tibetan Zone.	Approximate foreign equivalents.	
ARYAN GROUP.	High level terraces of the chief Himālayan rivers; Karewas of Kashmīr; Ossiferous beds of Ngari Khorsum.			Pleistocene.	POST TERTIARY.
	Siwālik series { Upper Siwālik stage. Middle Siwālik stage. Lower Siwālik (N ā h a n) stage.			Pliocene.	TERTIARY.
				Miocene.	
	Sirmūr series { Kasauli stage. Dagshai stage. Subāthu stage.	Intrusive tourmaline-granite, biotite-granite and hornblende-granite.		Oligocene.	
			Nummulitic limestone of Zangskar and Ngari Khorsum, and volcanics of Lake Mānasarowar; Indus Valley Tertiaries; upper part of Kampa system.	Eocene.	
			Chikkim series; Flysch of Ngari Khorsum; Upper Cretaceous of Afghānistān; Middle Cretaceous of Afghānistān; Giumal series; lower part of Kampa system; Red Grit series of Afghānistān; Lower Cretaceous of Central Tibet.	Cretaceous.	MESOZOIC.
	Tal series.		Spiti shales and Jurassic of Tibet. Saighan series of Afghānistān. Kioto limestone. { Tagling stage. Para stage. Angara slates	Jurassic.	
			Trias of Hazāra and Kashmīr. Lilang system.	Trias.	
	Gondwānas of Eastern Himālaya.	Krol; Infra-Trias; Infra-Krol; Blaini boulder-bed.	Kuling system. { Productus shales. Calcareous sandstone. Conglomerates. } Zewan stage. Fusulina limestone of Afghānistān and Chitrāl. Gangamopteris beds. Panjāl volcanics.	Permian.	PALÆOZOIC.
DRAVIDIAN GROUP.			Kanāwār system in Spiti. { Po series. Fenestella shales. Lipak series. Syringothyris limestone.	Carboniferous.	
		Deoban and Jaunsār series ?	Hajigak limestone, Afghānistān. Chitrāl limestones, Sarikol shales.	Devonian.	
			Muth system { Muth quartzite. Limestone with Silurian fossils. Red quartzite. Conglomerate in Spiti. Coral limestone in Kumaun.	Silurian.	
			Haimanta system. { Upper Haimanta. Middle Haimanta. Lower Haimanta.	Middle Cambrian, Lower and perhaps in part pre-Cambrian.	
PURĀNA GROUP.		Carbonaceous system; Simla, Attock and Dogra slates; Baxa series; Miju beds.		ALGONKIAN.	
ARCHÆAN GROUP.		Jutogh series; Salkhala series; Daling series; old schists, gneisses and crystalline limestones.	Vaikrita system in part.	ARCHÆAN.	

CHAPTER 31

THE SUB-HIMĀLAYAN ZONE.

Although it is customary in stratigraphical treatises to deal first with the oldest rock-groups, it will be more convenient in the present instance to take the three zones in their geographical sequence, describing them in the order in which they would be met with by the traveller passing from the plains of India to the highlands of Tibet. Whether his route lies through the tropical forests of the Darjeeling Terai, the sal-covered spurs above Kāthgodām, the outer ridges and dūns of the Siwālik range below Mussoorie, or the sinuous tunnels of the Kālka-Simla Railway, he must always cross a band of conglomerates, sandstones and clays, which runs from end to end of the Himālaya along their outer margin, and is known to geologists as the Sub-Himālayan zone. Even should his destination be the valley of Kashmīr, he must still cross the same zone in the Murree hills and through the deep and narrow gorges of the Jhelum.

Subdivisions of the component beds.—The rocks of this zone fall into two well-marked subdivisions, known as the Sirmūr and Siwālik series, respectively: these, again, are subdivided as follows:—

Sub-Himālayan system	Siwālik series	Upper Siwālik stage (Pliocene).	
		Middle Siwālik stage (Pontian and Sarmatian).	
		Lower Siwālik (Nāhan) stage (Tortonian).	
	Sirmūr series	Kasauli stage	Murree (Helvetian and Burdigalian).
		Dagshai stage	
		Subāthu stage (Lutetian).	

Sub-Himālayan System.

Siwālik series.

Upper Siwāliks.—The upper, or Siwālik, series is the first rock-group met with in passing from the plains into the Himālayan foot-hills, and takes its name from the Siwālik hills, which are composed of the various members of this series. The uppermost stage consists of an immense thickness—six to nine thousand feet—of loosely aggregated conglomerates and soft earthy beds immediately underlying, but, as a rule, sharply marked off from, the extensive recent deposits still in process of formation along the foot of the Himālaya. Here and there, however, where the Siwālik beds have been subjected to comparatively little disturbance, no distinct line of division between them and the overlying recent deposits can be found, and, owing to the mutual similarity of composition, we are led to conclude that the recent deposits are the direct successors of the Upper

Siwālik beds. Both are of sub-aërial origin, and both are the direct products of those forces of which the concrete embodiments are rain and rivers, and which are to-day at work, removing material from the mountains to lay it down again on the plains at their foot. To this process not only the recent deposits, but clearly also the Upper Siwāliks, owe their origin. It has further been found that, in the neighbourhood of the debouchures of the great rivers of the present day, the Siwālik deposits consist chiefly of coarse conglomerates, whereas, in the intervening areas soft earthy beds predominate [*Manual of the Geology of India*, 2nd edition, 358 (1893); H. B. Medlicott: *Records, Geological Survey of India*, Vol. IX, 57 (1876)]. It is clear, therefore, that, throughout the vast period of time necessary for the accumulation of these deposits, the distribution of the main drainage lines of the Himālaya was much as it is at the present day, and the more important Himālayan rivers are therefore of very great antiquity.

Middle Siwālik and Nāhan stages.—The Upper Siwālik conglomerates are underlain by a great thickness of a soft, barely coherent, sand-rock [C. S. Middlemiss: *Memoirs, Geological Survey of India*, Vol. XXIV, pt. 2 (1890)], lying upon a harder but otherwise very similar sandstone: these two subdivisions of the Siwālik series are known as the Middle and the Lower, respectively, the latter being also frequently known as the Nāhan stage, from its being exposed and having been first studied at Nāhan [H. B. Medlicott: *Memoirs, Geological Survey of India*, Vol. III, pt. 2 (1864)].

Siwālik fossils.—As already stated, the three stages forming the Siwālik series are all composed of sub-aërial deposits which bear internal evidence of a fluviatile origin. As might, therefore, be expected, fossils are rare, but the two uppermost stages have yielded locally large numbers of remains of mammals closely allied to species existing in the Himālayan foot-hills at the present day. These include bones and teeth of such animals as the elephant, rhinoceros, tiger, pig, ox and various species of deer [Falconer and Cautley: *Fauna antiqua sivalensis*; also *Palæontologia Indica*, ser. X], as well as a great variety of ancestral types of mammals and reptiles, many of gigantic size. Such fossils are by no means of common occurrence, but the few localities which have hitherto been discovered have yielded them in some profusion. The same belt of Siwālik deposits is known to extend far to the west, through the Punjab into Sind, whilst similar beds, also locally fossiliferous, have been found in Burma. There is an extensive literature on the subject of the Siwālik fossils, chiefly the researches of Dr. G. E. Pilgrim, and it is generally agreed that they are of the same age as the very similar fossils found in Europe and this determines the age of the Siwāliks to be from the Middle Miocene to the top of the Pliocene.

Middle Siwāliks.—The beds below the Upper Siwālik conglomerates—the Middle Siwālik or sand-rock stage—are composed chiefly of soft sands of a "pepper and salt" colour; here and there they contain small masses of lignite, which have frequently led to expectations of coal; such expectations, however,

have invariably proved fallacious, and in all cases the lignite deposits have been found to be merely isolated pockets of carbonised wood [H. B. Medlicott: *Memoirs, Geological Survey of India,* Vol. III, pt. 2, 14 (1864) ; C. S. Middlemiss : *Memoirs, Geological Survey of India,* Vol. XXIV, pt. 2, 26 (1890) ; H. H. Hayden : *Records, Geological Survey of India,* Vol. XXX, 249 (1897)] or, in a few instances, patches of drifted vegetable matter [F. R. Mallet: *Memoirs Geological Survey of India,* Vol. XI, 46 (1875)] far too small to be of any economic value.

Nāhan stage.—The lowest, or Nāhan, stage differs from the Middle Siwālik in its greater degree of induration and at times also in its colour, the prevailing tints being brownish and greenish-brown, although bluish-grey is not uncommon, especially on weathered surfaces ; the safest criterion by which to distinguish the members of the two groups, one from the other, is the greater degree of hardness characteristic of the Nāhan sandstone, which is capable of being dressed into blocks and used as a building material, whereas the sand-rock is much less coherent and crumbles away when struck with the hammer.

Lithological characters of the three stages.—Although the three stages of the Siwālik series may be denoted broadly as the conglomerate, sand-rock and sandstone stages, respectively, yet it must not be supposed that each of these rocks constitutes the whole of the formation of which it is characteristic ; these are merely predominant types, and conglomerate is found also in the sand-rock stage, especially towards its base, as well as in the Nāhan stage, whilst clay and loam are found throughout the whole series, purple and red clays being especially characteristic of the Nāhan stage.

Main boundary fault.—Between the Siwālik series and all older beds with which they are found in contact there occurs one of the most peculiar, as it is one of the most constant, features of Himālayan tectonic geology. This is known as the "main boundary fault", which, probably throughout the whole length of the Himālaya, from Assam to as far as Kotli, in the Jammu State, occurs at the inner edge, and so forms the northern boundary, of the Siwālik series. Near Kotli, the thrust-plane boundary between the Middle Siwāliks and the Murrees dies out in a normal fold, and the limit of deposition between them disappears, the passage of one into the other being gradual and the boundary between becoming indefinite. This fault has many peculiar and interesting features: in the first place, it is not a simple fault, but is of the type known as "reversed", along which, in the process of folding, the older rocks have been thrust up over the younger, whilst, at the same time, the apparent order of superposition of the beds on one or on both sides of the fault may be exactly the reverse of the order in which they were originally deposited. Whatever be the ultimate causes to which the folding of the crust of the earth is due, they resolve themselves finally into tangential thrusts acting in opposite directions ; the effect of this is to throw the crust into folds, which, at first gentle, gradually become more and more compressed until the pressure exceeds the breaking strain of the component rocks

and fracture (faulting) results. This is most readily exemplified by means of diagrams; on Plate XXXIX, figures 1 to 3 represent successive stages in the compression and folding of a series of stratified rocks, from their simple wave-like beginnings up to the reversed and broken flexure which is the key to almost all the complicated puzzles of Himālayan structure, not only in the geologically young Sub-Himālayan area but also throughout the whole of the mountain masses between India and Tibet, as well as in the ranges of Afghānistān.

Character of the faults.—If, now, we turn to the actual conditions of the rocks of the Sub-Himālayan zone, we find this type of structure clearly shown in the beautiful sections traced by Mr. Middlemiss in the area between the debouchure of the Ganges and Nepāl. Plate XXXIX, figures 4 to 6, which are reproductions of Mr. Middlemiss' sections [*Memoirs, Geological Survey of India,* Vol. XXIV, pt. 2 (1890)], show not only one of these reversed faults but a whole series of them (figure 6), each separating one rock formation from another and occurring not only among the members of the Siwālik series, but also through the older beds of the unfossiliferous and metamorphic zone of the Lesser Himālayan ranges. It will be noticed that each of these fractures has taken place along the middle limb of the fold, *i.e.*, along the part lying between an anticlinal crest and its complementary synclinal trough, and that on either side of the fault the normal order of superposition of the beds has, in many cases, been reversed, the younger now appearing to underlie and dip beneath the older; this is a characteristic and constant feature in the relation of the beds of the Siwālik series to all older beds and also to a great extent, to one another. At Kotli in Jammu Mr. Middlemiss [*Records, Geological Survey of India,* Vol. L, pt. 2, pp. 122-125 (1919)] has worked out the actual angle of the thrust-plane dividing the Murrees from the Siwāliks to be 12 to 15 degrees from the horizontal.

Main boundary fault an original limit of deposition.—A second point of importance in connection with the main boundary fault lies in the fact that the Siwālik deposits never overstep this boundary line and are never found among the higher hills beyond, but are restricted to the zone fringing the foot of the hills. The main boundary must, therefore, mark an original limit of deposition of the Siwālik series. Furthermore, Mr. Middlemiss has inferred that the reversed faults lying to the south of the main boundary are also to a certain extent original limits of deposition for the beds lying immediately to the south of each, and that they consequently mark the approximate position of the mountain-foot as it was at the time of their formation. They were thus "not contemporaneous, but successional", each having been produced or at least completed at the end of the period during which the beds immediately to the south of it were deposited [C. S. Middlemiss: *Memoirs, Geological Survey of India,* Vol. XXIV, pt. 2, 118, 119 (1890)]. The detailed reasoning and careful observation which have led to the above conclusions and which we owe, first, to the genius of the late Mr. H. B. Medlicott, and subsequently to the skill and industry of Mr. C. S. Middlemiss,

are too extensive and of too technical a nature to be dealt with here, but those who wish to pursue the matter further are referred to the original papers [H. B. Medlicott : *Memoirs, Geological Survey of India*, Vol. III, pt. 2 (1864) ; C. S. Middlemiss : *Memoirs, Geological Survey of India*, Vol. XXIV, pt. 2 (1890)]. An admirable summary, by Mr. R. D. Oldham, of the whole question will be found in the second edition of the "Manual of the Geology of India", pp. 467 to 471.

Mode of accumulation of the Siwāliks.—Turning now to the Siwālik series as a whole, we find it to consist of an enormous thickness—averaging over 16,000 feet—of deposits, which, in spite of local unconformities, are undoubtedly one great conformable and connected formation, [C. S. Middlemiss : *Memoirs, Geological Survey of India*, Vol. XXIV, pt. 2, 29 (1890)], which has been deposited sub-aërially by streams and rivers [*Manual of the Geology of India*, 2nd edition, 358 (1893)] along the outer margin of the Himālaya. The deposition of such a great thickness of material must have occupied a vast period of time, during which the area over which they were being laid down was steadily sinking.

Rev. O. Fisher's theory.—The cause of this persistent movement of subsidence is still a matter of controversy, and no theory has been universally accepted, although that put forward by the Rev. O. Fisher had until a few years ago many supporters. This has already been ably dealt with by Mr. Oldham [*Manual of the Geology of India*, 2nd edition, 471 to 477 (1893)], whose modification of the theory seemed to satisfy all the requirements of the case. The theory is based on the hypothesis that the crust of the earth is comparatively thin, and rests upon a zone of material which is either fluid or has the properties of a fluid. As this inner portion contracts owing to loss of heat, the crust is left unsupported and, not being strong enough to bear the strain due to its own weight, will "yield along lines of weakness" and be "thickened both upwards and downwards" from a zone at certain depths below the surface. Above this zone, which has been termed the "neutral zone", "the material will, on the whole, be forced upwards and below it downwards ". Mr. Fisher has most ingeniously explained not only the rise of the Tibet plateau but also the overfolding of the outer border of the Himālaya and the subsidence of the submontane tracts, whilst Mr. Oldham's amplification of the argument affords a complete explanation of all the observed phenomena [*Manual of the Geology of India*, 2nd edition, 473 (1893)].

Dutton's theory of isostasy.—Of late, however, physicists have begun to question the validity of Mr. Fisher's premises and Major Dutton's theory of isostasy has gained general support. According to this it is assumed that, owing to the removal, by rain and rivers, of material from the mountains and its deposition on the plains at their foot, isostatic equilibrium has been disturbed and can be restored only by the rise of the denuded area and the subsidence of that portion over which the material has been deposited ; we thus have an

explanation of the manner in which these vast sub-aërial deposits may have accumulated in areas which have for a long period of time been steadily subsiding.

Sirmūr series.

Kasauli stage.—The Sirmūr series is, with one exception, not known to occur to the east of the Jumna, but is extensively developed in the outer portion of the Lesser Himālaya to the west of that river. It has been subdivided into the three stages already noted. Of these, the uppermost, or Kasauli, stage consists chiefly of sandstone, with subordinate beds of clay: the sandstone is grey or greenish in colour, at times hard, but, as a rule, rather soft and coarse, the upper beds being not unlike the sandstones of the Nāhan stage. The apparent absence of marine fossils, the presence of remains of land plants, and the general similarity of the beds of the Kasauli stage to those of the lower beds of the Siwālik series leave little room for doubt that the Kasauli sandstone is of fresh-water origin. The stage takes its name from the hill station of Kasauli, where it is well exposed.

Dagshai stage.—The underlying Dagshai stage consists chiefly of grey or purple sandstone with beds of bright red or purple homogeneous clay. Both at Dagshai and on the ridge to the north of that station the beds are well exposed and readily recognisable in the road and railway cuttings. The only fossils found are worm-tracks and obscure markings ascribed to fucoids. It appears probable that these beds were deposited in lagoons or salt-water lakes: they thus constitute an intermediate stage between the overlying Kasauli beds of fresh-water origin and the underlying Subāthu stage, which is definitely marine. The Kasauli and Dagshai stages, and the corresponding Murree beds, may be taken as Middle and Lower Miocene.

Subāthu stage.—The Subāthu stage—so named from the hill station of Subāthu—consists chiefly of "greenish-grey and red gypseous shales, with some subordinate lenticular bands of impure limestone and sandstone, the latter principally found near the top" of the stage [*Manual of the Geology of India*, 2nd edition, 350 (1893)]. At the base there is a peculiar ferruginous bed which bears a strong resemblance to the laterite so well known in the Indian peninsula. Fossils are common throughout the rocks of this stage, especially in the neighbourhood of Subāthu [H. B. Medlicott: *Memoirs, Geological Survey of India*, Vol. III, pt. 2 (1864)]. The only forms that need be mentioned here are *Nummulites*, the presence of which leads to the inference that the Subāthu stage corresponds to the Eocene of Europe.

Near the base of this stage at Subāthu, there is a seam of coal, which, however, is too impure and too crushed to be of any economic value [*Manual of the Geology of India*, 2nd edition, 350 (1893)].

Distribution of the Sirmūr series.—The Sirmūr series was first critically examined and described by Mr. Medlicott (*op. cit.*) in the Simla region; it was subsequently traced by him westwards into Jammu [*Records, Geological Survey of*

India, Vol. IX, 53 (1876)] and thence linked up with the similar rocks of Murree and the Jhelum valley [A. B. Wynne : *Records, Geological Survey of India,* Vol. VII, 64 (1874) ; O. Feistmantel : *Records, Geological Survey of India,* Vol. XV, 51 (1882)].

The Sirmūr series of Jammu is similar to that of the Simla region, with the exception that the coal seams of the Subāthu stage are here more extensive, and are underlain by thick beds of ironstone [R. R. Simpson : *Memoirs, Geological Survey of India,* Vol. XXXII, pt. 4 (1904)].

In the Murree hills nummulitic limestone and shales represent the Subāthu stage, whilst the two upper stages (Dagshai and Kasauli) are represented by the formation known as the Murree beds, the identity of part of which with the Kasauli stage has been proved by the occurrence in the Murree hills of fossil plants similar to those found in the Kasauli stage in the Simla region [O. Feistmantel : *Records, Geological Survey of India,* Vol. XV, 51 (1882)]. Similar fossils have also been found in the valley of the Rāvi [H. B. Medlicott : *Records, Geological Survey of India,* Vol. IX, 52 (1876)], which thus serves as a connecting link between the Murree and Simla regions.

Age of the series.—The whole of the Sirmūr series appears to be one perfectly continuous and conformable group of deposits, no unconformity having been recognized from the Subāthu stage up into the Dagshai stage and thence from that into the Kasauli stage. The evidence afforded by fossils enables us to correlate the Subāthu stage with the Lutetian stage of the Eocene of Europe [D'Archiac and Haime : *Groupe nummulitique de l' Inde*] and the Kasauli and Dagshai stages mainly with the Lower Miocene.

Its eastern development.—It has already been pointed out that, to the east of the Jumna, the Sirmūr series is only known to occur in one area. To the east of the debouchure of the Ganges and along the inner boundary of the Siwālik series, there is found a most complicated group of beds, amongst which the typical beds of the Subāthu stage have been recognised not only by their lithological characters but also by their fossils [C. S. Middlemiss : *Records, Geological Survey of India,* Vol. XX, 33 (1887), *Memoirs, Geological Survey of India,* Vol. XXIV, pt. 2 (1890)].

Relation of Sirmūr series to older rocks.—Where the Sirmūr series has been found in contact with older beds, the junction between the two has always been found to be either a faulted or an unconformable one. Nevertheless, from a tectonic point of view, this series is more nearly associated with the old, frequently metamorphosed, beds of the central zone of unfossiliferous sediments, amongst which its component members have been intimately infolded, than with the younger Siwālik series, and it extends beyond the strictly Sub-Himālayan hills into the ranges of the Lesser Himālaya, whilst, except in the western parts of the Himālayan area, it is marked off from the Siwālik series by the sharp line of the "main boundary". In all except its purely structural relations, however, it

differs widely in every respect from the old unfossiliferous rocks of the Himālayan zone.

Tal Series and Himālayan Gondwānas.

Before passing on to deal with the component parts of this latter zone, we must refer briefly to certain pre-Sirmūr beds which are, from a stratigraphical point of view, more nearly related to this younger series than to the members of the older Himālayan zone. These include a small patch of beds immediately underlying the Subāthu stage in western Garhwāl to the east of the Ganges, and certain coal-bearing beds found along the southern foot of the Himālaya to the east of the Nepāl Terai. The first of these is known as the "Tal series", and the latter comprise a small fragment of the well-known Gondwāna system of Peninsular India.

Tal series (Plate XLII).—The Tal series was first noticed by Mr. H. B. Medlicott in the valleys of the Tal and Bedasni rivers, affluents of the Ganges in western Garhwāl [*Memoirs, Geological Survey of India,* Vol. III, pt. 2, 69 (1864)], and was subsequently traced for some distance in an easterly direction by Mr. C. S. Middlemiss [*Records, Geological Survey of India,* Vol. XX, 33 (1887)]. It comprises two subdivisions: a lower composed of sandstone, some conglomerate and a black carbonaceous shale containing plant remains, and an upper, indigo-coloured, calcareous grit, at times becoming a sandy limestone, full of broken marine fossils. On normal sections, this series lies immediately below the nummulitic beds of the Subāthu stage, and is therefore older, whilst the fossils, which are unfortunately too badly preserved for complete determination, indicate that it might possibly be referable to some part of the Jurassic system or at least to some member of the Mesozoic group of Europe. It is to be hoped, however, that fossils in a better state of preservation may yet be found in this area, and thus enable us to ascertain the exact age of this series, which is unique in comprising the only fossiliferous marine beds of pre-Tertiary age known to occur in close association with the unfossiliferous series of the Himālayan zone.

Gondwānas in the Eastern Himālaya.—Along the southern foot of the Eastern Himālaya, from the Balasan river, which debouches at a few miles to the east of the Nepāl frontier, up to the Dikrang river in the Dafla hills on the Assam border, a band of highly crushed coal-bearing rocks has been found, first by Lieutenant-Colonel Godwin-Austen [*Journ. As. Soc. Bengal,* Vol. XLIV, pt. 2, 35 (1875)] in the extreme east, and subsequently by Mr. F. R. Mallet [*Memoirs, Geological Survey of India,* Vol. XI, 14 (1875)] in the Darjeeling Terai and the Duārs, by Mr. G. E. Pilgrim [*Records, Geological Survey of India,* Vol. XXXIV, 24 (1906)] in the foot-hills of Bhutān, by Mr. T. D. LaTouche [*Records, Geological Survey of India,* Vol. XVIII, 122 (1885)] in the Aka hills and by Dr. J. Coggin Brown in the Dihāng valley [*Records, Geological Survey of India,* Vol. XLII, 231 (1912)]. The rocks of this series consist of sandstone, shale and coal, which, owing to the

intense crushing to which they have been subjected during the building up of the Himālaya, have been locally changed to quartzites, slates and carbonaceous schists. The coal beds, being the softest, have suffered most, and have been rendered so friable that they crumble into powder with the least handling; at the same time what were once probably continuous beds have been squeezed out into lenticular patches; these characteristics detract largely from the economic value of the coal-seams, and have rendered futile all attempts at mining enterprise. A number of fossils have been found in these rocks in the Darjeeling area and include such well-known genera as *Vertebraria* and *Glossopteris* [F. R. Mallet: *Memoirs, Geological Survey of India*, Vol. XI, 30 (1875)], plants eminently characteristic of the coal-measures of Bengal. On the whole, the fossils, as well as the lithological characters of the rocks in which they occur, offer conclusive proof that these Himālayan beds represent the Dāmuda series of the Lower Gondwāna system. The importance and interest of this group of beds are obvious, since they afford evidence of the north-easterly extension of the old Gondwāna continent. Dr. J. Coggin Brown has described an association of basalts, with these Gondwānas in the Abor hills [*Records, Geological Survey of India*, Vol. XLII, 241-244 (1912)].

Distribution of the Gondwānas.—How far this belt of Dāmuda rocks is continuous along the foot of the Eastern Himālaya, it is at present impossible to say; but since it has been met with at most points at which the lower hills have been visited between the eastern frontier of Nepāl and the Dikrang river, it is highly probable that its continuity is practically uninterrupted, whilst it may not improbably extend still further towards the east. The whole of the Eastern Himālaya, however, from the Sankosh river to the gorge of the Brahmaputra, is practically a *terra incognita*, in which much work of absorbing interest still remains for the geographer as well as for the geologist. Towards the west also these beds may possibly extend into Nepāl, but of this there is no evidence. The only part of the country regarding which we have any information is the strip bordering the road to Kātmāndu, along which Mr. Medlicott found the Siwālik series well developed, but could not definitely identify any part of the section seen by him as being of Gondwāna age [*Records, Geological Survey of India*, Vol. VIII, 93 (1875)]. No trace of the latter system has been found anywhere along the foot of the Himālaya to the west of Nepāl, the only other extra-peninsular area in which plant-beds of Gondwāna age have been identified being the valley of Kashmīr (see below, p. 316).

CHAPTER 32.

THE HIMĀLAYAN ZONE.

Distribution and subdivision.—The next great group of rocks, which occupies what is known as the Himālayan zone, forms the bulk of the ranges constituting the Himālaya proper, and stretches from end to end of this mountain chain. To visitors to the hill stations it is the most familiar, yet at the same time the least understood, of all the Himālayan rock-groups and its classification still constitutes the greatest and most insoluble of all problems of Himālayan geology. It falls broadly into two subdivisions, (1) metamorphics, composed of granite gneiss and crystalline schists and (2) a series of fragmental rocks of undoubtedly sedimentary origin, such as slates, quartzites, conglomerates and limestones, which, although frequently, to all appearance, eminently suited for the preservation of fossils, have not yet yielded to the most careful and repeated search a single trace of any undoubted organic remains.

The absence of fossils throughout the Himālayan zone renders it impossible to correlate, with any degree of certainty, the various rocks of one area with those of another, since all attempts at such correlation can be based only on the individual peculiarities of the rocks themselves, that is to say, on their lithological characters, a method which, in the case of stratified rocks of undoubted sedimentary origin, is always more or less unreliable and not infrequently misleading, especially in areas in which disturbance and metamorphism are so pronounced as in the central zone of the Himālaya. The result of this is that, with rare exceptions, it has been impossible to recognise with certainty the lithological elements of one area in those of another, and a large number of apparently independent rock-groups have consequently been established, each under a purely local name, thus giving rise to a confusing variety of subdivisions, no two of which can be definitely correlated the one with the other. Of these the best known are the "Simla slates" and "Carbonaceous system" in the Simla hills and Mussoorie, the "Jaunsār system" in Jaunsār-Bāwar, the "Purple slates", "Deoban limestone" and "Vaikrita system" of Garhwāl and Kumaun, the "Baxa" and "Daling" series in the Darjeeling Himālaya and the slates and schists of the Miju ranges between North-Eastern Assam and Tibet.

Granite and Crystalline Schists.

Crystalline belt.—In striking contrast with the amount of detailed attention that has been paid to the unfossiliferous sediments of the Himālayan zone, the metamorphosed schists and other crystalline rocks have, with one exception, been most strangely neglected. This has no doubt been largely due to the fact that the crystalline rocks, as a rule, lie in that "no man's land" between the

sedimentary Himālayan systems and the fossiliferous beds of the Tibetan zone, and have thus, owing to lack of time and opportunity, failed to receive attention at the hands of the respective investigators of these two belts of rocks.

Gneissose granite.—The one exception referred to is that of the gneissose granite of the Himālaya, which was most exhaustively studied by the late Lieutenant-General C. A. McMahon, whose work is a monument of patient investigation and a brilliant example of the great assistance that can be rendered by a non-professional worker in the field of Indian geological research. Of the many valuable results of General McMahon's work, the most important of all was the conclusive proof of the intrusive origin of the granite, which had hitherto been regarded as a metamorphic rock of probably sedimentary origin, and, under the name of the "central gneiss", [F. Stoliczka: *Memoirs, Geological Survey of India,* Vol. V (1866)] had been described as the oldest of all Himālayan rocks, whereas he was able to show that it was in reality one of the youngest members of the Himālayan and Tibetan zones, into which it had been intruded, and with which it had been intimately infolded, whilst to it is due much of the metamorphism of the rocks amongst which it occurs.

Age of the granite.—The period at which the intrusion of the Himālayan granite took place is not definitely known, but is usually regarded as approximately coincident with the disturbances to which the origin of the Himālaya is ascribed and which occurred towards the end of the Eocene division of the Tertiary period.

Pre-Carboniferous granite of Spiti and Kashmīr.—Fragments of granite have been found among the pebbles of the conglomerates in the old "Panjāl" rocks of Kashmīr and in the "Kuling system" in Spiti; it is therefore evident that granite must have formed part of the land surface from which the materials that make up these beds were derived and must consequently have been older than Carboniferous. It will be seen subsequently that at this period the Himālaya did not exist and this old granite must therefore be excluded from the term "Himālayan".

Other granites.—Three other granites are found in the Himālayan region. The best known of these is characterised by the presence of biotite (black mica) and the absence of the mineral hornblende. It forms almost all the high peaks of the great Himālayan range and is the form commonly understood by the term "Himālayan granite". Associated with it is another granite characterised by the presence of black tourmaline (schorl), plagioclase felspar and beryl; this rock occurs in the form of bands intruded into the biotite-granite and is therefore younger than the latter; the difference in age between the two, however, is probably not great, the tourmaline-granite being perhaps merely the residual portion of the magma which still remained molten after the separation of the biotite-granite, in which case they may be regarded as merely representing two stages of a single phase of intrusion.

The remaining granite differs markedly in mineralogical characters from both of the foregoing and is especially characterised by the presence of hornblende and sphene. It was found to be common in the valleys of the Brahmaputra and Kyi Chu in the neighbourhood of Lhāsa [H. H. Hayden : *Memoirs, Geological Survey of India*, Vol. XXXVI, pt. 2 (1907)] and has also been noticed in the Upper Indus valley in Ladākh, in Astor, in Gilgit [C. A. McMahon : *Quarterly Journal, Geological Society*, Vol. LVI, 340 (1900)] and again in the Hindu Kush in Afghānistān. In Tibet it was regarded as possibly a form of the common biotite-granite of the Himālaya modified by the absorption of lime from the rocks into which it had been intruded; but the type has now been found to persist over such a wide area that this explanation of its origin seems hardly satisfactory, and it should perhaps be regarded as a definite petrological type. The age of the hornblende-granite is not known with certainty; it has been shown by General McMahon to be older than the typical biotite-granite and was found in Tibet to be either later Cretaceous or post-Cretaceous. There is, therefore, no great difference in age between these granites and all three may possibly have been derived, by a process of differentiation, from the same magma, the hornblende-granite solidifying first, the biotite-granite next, and the tourmaline-granite last of all. The result of this is that each of the two older is penetrated by veins of the younger.

Extension of the biotite-granite.—It has already been pointed out (*supra*, p. 289) that the axis of the great Himālayan range, the line of highest peaks, lies on a continuous zone of granite and associated crystalline rocks : this belt extends for some distance on either side of the axis and separates the old Himālayan sedimentary systems from the Tibetan zone to the north, at the same time sending out ramifications in all directions into both. Thus the granite extends down into Chamba on the west, to the Chaur peak between Simla and Mussoorie, far south into Nepāl, Darjeeling and the Chumbi valley, and probably composes much of the mountains of Bhutān and the unknown regions further to the east.

Nature and origin of the crystalline schists and their distribution.—The associated crystalline rocks can, to a certain extent, be proved to be merely the metamorphosed representatives of the adjacent sedimentary systems. This is especially the case in the western part of the Himālayan belt, as, for instance, in the valley of the Sutlej in Kanāwār, where the kyanite-schists and garnetiferous mica-schists bordering on the fossiliferous system of the Tibetan zone are seen to pass horizontally into comparatively unaltered beds which belong structurally to the Haimanta system [H. H. Hayden: *Memoirs, Geological Survey of India*, Vol. XXXVI, pt. 1, 9 (1904)] (see below, p. 301).

Further to the east, in Kumaun and Garhwāl, a schistose series has been described under the name of the Vaikrita system [C. L. Griesbach : *Memoirs, Geological Survey of India*, Vol. XXIII, 41, 150 (1891)] part of which is probably of similar origin. Still further eastwards, in Northern Sikkim and the Assam

Himālaya, this relationship between the granite and contiguous sedimentary beds is still traceable, but such metamorphism as can be ascribed with certainty to the granite extends but a short distance out from the intrusive masses of this rock, and we are not justified in assuming that such rocks as compose the crystalline complex of the Upper Tīsta valley are the result of a single effort of contact-metamorphism. These include such types as pyroxene-granulite, graphitic biotite-gneiss and spinel-bearing crystalline limestone, all of which occur in the valley of the La-Chen river in Sikkim [H. H. Hayden: *Memoirs, Geological Survey of India*, Vol. XXXVI, pt. 2 (1907)], whilst pyroxene-gneisses have also been found by Dr. L. L. Fermor in the neighbourhood of the Pindari glacier in the Almora district of Kumaun [*ibid.*] and presumably, therefore, amongst the rocks constituting the Vaikrita system.

Between these two areas, crystalline limestone and other metamorphic rocks are known to occur in the valley of Nepāl [H. B. Medlicott: *Records, Geological Survey of India*, Vol. VIII, 96 (1875)] and may possibly be the representatives of the rocks of the La-Chen valley in Sikkim. Crystalline limestones have also been brought by Mr. Claude White from Bhutān.

Origin and relationships of the crystalline schists.—Thus we may regard the crystalline belt as composed of three elements, *viz.*, intrusive granite, metamorphic schists due probably to the action of the granite on the rocks into which it has been intruded and which it has partially absorbed, and, lastly, a series of old gneisses, schists, granulites and crystalline limestones, of which the advanced state of metamorphism cannot be attributed merely to the Himālayan granite. These latter rocks, in fact, bear a marked resemblance to certain Peninsular types which are found in Madras, Burma, Ceylon, the Central Provinces [the pyroxene-gneiss found by Dr. Fermor near the Pindari glacier is said to be indistinguishable from similar rocks from the Central Provinces] and Rājputāna, and which are referred to the Archæan, the oldest of all the Indian rock-groups. Far to the west, in North-Eastern Afghānistān, the Siāh Koh and the mountain ranges to the south and west of Kābul are either completely formed of similar types or have a foundation of these old rocks upon which younger fossiliferous beds have been unconformably deposited. In the intermediate areas crystalline schists are found in Hazāra [C. S. Middlemiss: *Memoirs, Geological Survey of India*, Vol. XXVI, 46 (1896)], Gilgit and Kashmīr [R. Lydekker: *Memoirs, Geological Survey of India*, Vol. XXII, 265 (1883)] and, though in part merely altered representatives of sedimentary beds, probably also include members of the Archæan group.

Thus it is difficult to escape from the conclusion that the axis of the Himālayan chain and of the associated ranges to the west is in part made up of true representatives of the oldest known group of rocks, and that these are merely the northerly extension of the similar rocks of the Indian Peninsula.

SEDIMENTARY SYSTEMS.

Sedimentary rocks of the Himālayan zone.—Throughout the whole of the Himālaya the crystalline axis is always separated by a belt of unfossiliferous sedimentary deposits from the band of Sub-Himālayan rocks which skirts the outer foot of the mountains. On the west, in Kāngra district, in the Simla hills, and thence as far as the Nepāl frontier, this belt occupies the greater part of the Lesser Himālayan ranges; to the east of Nepāl, however, the crystalline rocks approach nearer to the plains and the width of the sedimentary belt is reduced (Plate XXXVIII). In the western areas it consists, as already pointed out, of a number of apparently unrelated groups denoted by local names, such as the "Jaunsār system", "Carbonaceous system", "Deoban limestone", "Purple slate and breccia series" and the "Massive limestone". In the east its component members are known as the "Daling" and the "Baxa" series, respectively.

Geology of Simla hills.—During recent years a detailed examination, which is still in progress, has been made of the Simla neighbourhood by Dr. G. E. Pilgrim and Messrs. W. D. West and J. B. Auden. The region is a highly complicated and difficult one on account of the great number of formations present, their usually unfossiliferous character and the way in which they are thrust over one another. The results of Messrs. Pilgrim and West's work up till 1927 are embodied in a memoir "The Structure and Correlation of the Simla Rocks" [*Memoirs, Geological Survey of India*, Vol. LIII (1928)] and certain subsequent modifications have been noted in the General Reports of the Geological Survey of India for 1928 [*Records, Geological Survey of India*, Vol. LXII, 164-168] and 1930 [*Records, Geological Survey of India*, Vol. LXV, 125-132.]. The following classification, which may be subject to alterations as the investigation progresses, has been provisionally adopted, with suggested correlations with Hazāra and Kashmīr.

Dagshai series . .	Purple sandstones and clays . . .		Lower Miocene.
Subāthu series . .	Shales, limestones, carbonaceous beds. Basal pisolitic laterite.		Middle Eocene.
	Unconformity.		
Krol series .	1. Massive blue limestone 2. Red shale . . 3. Limestone and shale	(Infra-Trias and Panjāl Trap).	Permo-Carboniferous.
Krol sandstone . .			
Infra-Krol beds . .	Slates with beds of quartzitic grit.	Upper Tanāwal . Agglomeratic Slate .	Upper Carboniferous and Lower Gondwāna.
Blaini limestone .	Pink magnesian limestone.		
Blaini conglomerate .	Slates with glacial boulders.	(Tālchir and Tanakki boulder-beds).	
	Unconformity.		

Deoban limestone . .			
Jaunsār series . . .	Slates, with pebbly quartzites.	(Lower Tanāwal)	Devonian ?
Simla slates . . .	Slates, with Kakarhatti and Naldera limestones.	(Attock and Dogra Slates).	? Cambrian and Pre-Cambrian.
Jutogh series . .	? Chail facies . . Jutogh facies .	(Salkhala series).	Pre-Cambrian.

Overthrusting and metamorphism.—The Jutogh series are moderately metamorphosed rocks, disposed in several flat recumbent folds of great amplitude. The intrusion of the Chor granite into them has produced a slight local increase in metamorphism, and this metamorphism is clearly subsequent to the recumbent folding. Metamorphism and folding are thought to be Archæan in age, and have nothing to do with the much later overthrusting, which is almost certainly post-Eocene. At Simla they are overthrust on the Chail, Jaunsār, Simla and Blaini series, there being at least three large "slides" in the district. Another thrust has brought Simla slates, Blaini beds, Infra-Krol sandstone and Krol rocks over Tertiaries and their floor of Simla slates.

Great difficulties in correlation are introduced by the varying stages of metamorphism to which the formations have attained before the overthrusting took place. Thus in the Simla hills the Chail series is very different in character from the Jutogh series, from which it is separated by an overthrust, while in Hazāra their supposed equivalents are so intimately associated that they cannot be separated. It is suggested that in the Simla hills these two units are the same in age, but were originally deposited in distant areas, and while *in situ* acquired different degrees of metamorphism, being subsequently brought into juxtaposition by overthrusting. The Blaini beds again become schistose, and the boulders crushed and flattened, so much so that they would hardly have been recognised as Blaini if they had not been traced continuously; the highly banded slates, with true cleavage, of the Jaunsārs, the Blaini and the Infra-Krol can hardly be distinguished from each other after they have been metamorphosed.

Jutogh series and Simla slates.—The Jutogh series is made up of a thick succession of quartzite and schist, known as the Boileauganj series in the Simla area, where it forms the greater part of Jakko above the Mall and underlies most of the town. There are also mica-schists and limestones. Associated with these are beds of black carbonaceous schist, which owing to its colour has often been mistaken for coal, and has led to vain expectations of the discovery of this mineral in Simla on the hill-side above the Ladies' Mile.

The Simla slates underlie the Jutogh series at Simla, though in reality they are believed to be younger; they are well exposed throughout the ridges and valleys

to the east of Simla, and are seen all along the road from Sanjauli Bāzār to Mashobra, as well as on the outer slope of Elysium Hill and the spurs below the Mall on the north-eastern side of Jakko.

Blaini boulder-bed and limestone.—Above the Simla slates, and probably in its natural superposition, is the Blaini boulder-bed and limestone. This is the most readily recognised member of the succession and has served as a means of correlating various exposures in widely separated areas throughout the Lesser Himālayan ranges. It consists essentially of a bed of slate—presumably originally deposited as a fine mud or silt—through which are scattered sometimes pebbles of white quartz, sometimes large boulders of quartzite and other rocks. The large size of these boulders and the fine-grained nature of the matrix in which they lie has led to a comparison of the Blaini "boulder-slate" with the "till" or "boulder-clay", a characteristic deposit among the Pleistocene glacial beds of Europe, and which was formed by the instrumentality of glaciers and floating ice during the Great Ice Age, a supposition which is strengthened by the occasional presence of scratches on the boulders, similar to those produced by the pressure of ice-gripped rocks upon each other. The limestone is thin and typically pink or buff in colour, but sometimes blue. A small outcrop of the limestone occurs at Simla, immediately opposite the gateway of "Snowdon", but the best exposures of it and the boulder-slate are on Summer Hill, a mile and a quarter north of Viceregal Lodge.

Age and correlation of the Blaini series.—We thus see that the unfossiliferous sedimentary belt is composed of a patchwork of more or less isolated groups of beds, no two of which can yet, with absolute certainty, be identified one with the other. For the most part they consist of perfectly ordinary sediments such as have been formed at all times during the earth's history, at least since its surface was divisible into land and water, and are still forming round the coasts and in the seas of the present day. Consequently, so far as these deposits are concerned, correlation depends on the manner of association of the respective deposits; thus, quartzites overlain by carbonaceous shales and limestones in one area are correlated with a similar sequence in another. This method of correlation by lithological characters is unfortunately open to many objections and cannot be relied on except over very limited areas. Where, however, a peculiar and uncommon form of deposit occurs in two neighbouring areas, we are on safer ground in correlating the one with the other, and it is chiefly this method that has been employed throughout the Himālayan unfossiliferous belt. The Blaini boulder-slate is generally admitted to be of glacial origin [T. H. Holland: *Records, Geological Survey of India,* Vol. XXXVII, 129 (1908)], and as boulder-beds of this character, now known as "tillites", are by no means of common occurrence, but have been formed under very special conditions, which are known to have recurred only at rare intervals in the history of the earth, the Blaini rock has been regarded as the key to the solution of the

mutual relationships of the respective members of the sedimentary rocks of the Himālayan zone and, with the exception of the supposed boulder-slate of the Jaunsār system, all similar beds in this belt have been referred to the Blaini series. Nor has this procedure been restricted to the rocks of the Lesser Himālaya; it has been extended to certain supposed boulder-beds found in Spiti, in the Panjāl system in Kashmīr, in the Infra-Trias of Hazāra and even so far afield as Chitrāl. All these have, by one observer or the other, been referred to the Blaini horizon, and this again has been correlated with the well-known Tālchir boulder-bed, which is of undoubted glacial origin and which occurs below fossiliferous deposits of known age in the Salt Range and at the base of the Gondwāna system of Peninsular India. The Blaini boulder-slate and its supposed representatives in other parts of the Himālaya have, therefore, all been referred to the Tālchir horizon, that is to say, to about the Upper Carboniferous epoch of the European geological time-scale. This method of endeavouring to fix the age of the Blaini boulder-slate and its supposed representatives is a perfectly legitimate one, and the conclusions arrived at have been accepted as offering a probable solution. The wide distribution of the Tālchir tillite, which has been identified both in Australia and South Africa, would justify its extension to the Simla area, but it must be remembered that in all other areas it is found associated with fossiliferous rocks of known age, and it is therefore difficult to account for the absence of fossils in the Blaini series; this might no doubt be attributed to the disturbance and crushing to which the Himālayan group as a whole has been subjected, were it not for the fact that beds no less crushed and altered have been found in other areas to retain their fossils in a recognisable state, whereas the rocks of the Himālayan zone, although often apparently eminently suited for the preservation of fossils, have not yielded so much as a trace of any structure that can be definitely pronounced to be of organic origin, much less any recognisable fossils.

With regard to the series older than the Blaini boulder-bed, it has already been pointed out (*supra*, p. 291) that rocks exactly resembling Archæan and other pre-Cambrian types of the Indian Peninsula and Burma have been found in Sikkim, Kumaun and Afghānistān, and it is reasonable to suppose that they would also be discovered in the intermediate areas; furthermore, the Daling series of Sikkim and the metamorphic and crystalline rocks of the Miju ranges at the extreme eastern end of the Himālaya have also been referred to well-known Peninsular types [J. M. Maclaren: *Records, Geological Survey of India*, Vol. XXXI, 181 (1904)] and we are thus led to correlate the older Himālayan groups with the old unfossiliferous and metamorphic beds comprised in the Archæan and Purāna groups [see table showing classification of Himālayan systems, *supra*, p. 278] of the extra-Himālayan areas, which include such systems as the Vindhyans, Cuddapahs, Dhārwārs and that embracing the old gneissose rocks of Rājputāna, the Central Provinces, Madras and Burma and so to regard

this unfossiliferous belt as a northerly extension of what has been one of the most permanent, as it is one of the oldest, continental areas of the globe.

The Tethys.—The presence, immediately to the north of this zone, of an extensive series of fossiliferous marine sediments, further points to the conclusion that here lay the southern shores of the Tethys, the sea which extended over most of Asia during Palæozoic and Mesozoic times. Its old littoral deposits can still be traced among the beds of the Tibetan zone and prove that much of the present Himālaya was a land surface even in early Cambrian times (see below, p. 335); and the unconformities and overlaps found at various horizons in the Palæozoic systems are indications of the vicissitudes through which this part of the ancient continent has passed.

Daling and Baxa series.—In the eastern Himālaya, the unfossiliferous rocks are represented by the Daling and Baxa series. The former consists of green and grey silky slate, quartzite and, occasionally, beds of hornblende-schist. These beds are much crushed and contorted, and frequently contain small deposits of copper-ore, which have long been mined in primitive fashion by the natives of the Darjeeling district. The series occupies the lower hills between the crystalline rocks of Darjeeling and the Dāmudas of the foot-hills (Plate XXXVIII, fig. 3), and extends up along the Tīsta valley into Sikkim; thence it runs eastwards into Bhutān and continues through the unknown ranges on the north of Assam. [F. R. Mallet: *Memoirs, Geological Survey of India*, Vol. XI, 39 (1875); P. N. Bose: *Records, Geological Survey of India*, Vol. XXIV, 217 (1891); T. D. La Touche: *op. cit.*, Vol. XVIII, 123 (1885); J. M. Maclaren: *op. cit.*, Vol. XXXI, 181-186 (1904); G. E. Pilgrim: *op. cit.*, Vol. XXXIV, 25-29 (1906); J. Coggin Brown: *op. cit.*, Vol. XLII, 246-251 (1912).]

In the foot-hills of Bhutān another set of rocks, composed chiefly of dolomitic limestone and quartzite and known as the Baxa series, from the hill-station of Baxa, is found between the Dāmudas and the Dalings. Neither of these series has yielded any fossils, nor have they any special lithological features in common with individual members of the subdivisions into which the unfossiliferous rocks of other parts of the Himālaya have been grouped. Like these latter, however, they are now referred to the pre-Cambrian systems of the Indian Peninsula, of which they probably constitute merely an outlying portion. The metalliferous Dalings in some respects resemble the Dhārwārs whilst the rocks of the Baxa series may find their nearest analogues among the members of the Cuddapah system.

Both the Daling and the Baxa series always appear to overlie the crushed representatives of the Dāmuda series and also the beds of the Sub-Himālayan zone, which fringe the southern mountain-foot. For this reason they were formerly regarded as possibly younger than the Dāmudas, but we now know that one of the most persistent features of the tectonic geology of the Sub-Himālayan zone is the manner in which the younger formations appear to dip below and

underlie the older beds in the higher hills, a feature which we have seen to be due to recumbent folds and reversed faults; and when we find that each higher member is more metamorphosed and more crushed than that below, we may safely assume that the apparent sequence is the reverse of the true one and that, as in the case of the Tal series and associated rocks in western Garhwāl, the Daling is in reality older than the Baxa series and the latter older than the Dāmudas.

CHAPTER 33

THE TIBETAN ZONE.

The most northerly of the three zones of the Himālaya embraces not only the northern part of this mountain range, but extends far into Tibet and comprises one of the most complete representations of the geological record to be found in the world, ranging, as it does, from almost the earliest period of which there have yet been obtained any unequivocal organic remains down to the Tertiary epoch. Between these extreme limits not a single period remains unrepresented, for, although there may be local gaps in one area, these are bridged over in another; and as a book may be restored in its entirety from a number of incomplete copies, so the geological record may, with the exception of a few pages at the beginning and a few at the end, be pieced together from the editions lying open in the mountains of Kumaun, Spiti and Kashmīr.

Distribution of the zone.—Throughout the Himālaya, this northern, or Tibetan, zone is met with almost everywhere immediately behind the crystalline axis—the line of the high peaks—of the great Himālayan range. It embraces the Ladākh and Zangskar† ranges with their intervening troughs, and extends far to the north, probably at least to the great lake basin of Tibet and possibly as far as the Kunlun range. It consists of a vast thickness—more than 20,000 feet—of sediments almost entirely of marine origin and represented by such rocks as slate, sandstone, conglomerate and limestone. Along its southern border it is in contact with the Himālayan granite, which throws out branches ramifying through and metamorphosing the component members of the sedimentary zone.

Early stratigraphical work in the Himālaya.—Fossils had long been known to occur to the north of the great Himālayan range, the sacred "saligram"* of the Hindus having been identified as an ammonite related to those found in the Jurassic beds of Europe, and as early as the year 1831, the presence of genera common in the European Palæozoic and Mesozoic systems had been recorded in the Himālaya [*Gleanings in Science,* Vol. III, 30 (1831.)]. No systematic work, however, was undertaken till some years later, when General Sir R. Strachey

* "Saligram" are ammonites brought into India chiefly from the Jurassic shales of Kumaun, Ngari Khorsum and the uplands of Tibet on the northern frontier of Nepāl. They are to be found in Hindu temples in India, and are also worn as charms. Among the Buddhists of Tibet they are also regarded as having magical properties and are used in certain mystic rites. Sarat Chandra Das also draws attention to the presence of fossils among the offerings to the gods in Densatil monastery near Samye on the Brahmaputra [*Journey to Lhāsa and Central Tibet,* edited by W. W. Rockhill, 299 (1904)]. In the Sedgwick Museum, Cambridge, Dr. F. R. Cowper Reed found certain fossils related to known forms from the Jurassic Spiti shales, with two with Triassic affinities, obtained about 1822 from the "Salagrammi River near Mooktinath". This appears to be the "Sulgranees" from which Dr. J. E. Gray's type specimens were obtained, and is a local name (Salagramma) for the river Gandak, which rises in Nepāl [T. H. Holland: *Records, Geological Survey of India,* Vol. XXXVII, pt. 3, 136 (1908)].

† Zangskar and Ngari Khorsum are spelt as Zaskar and Nari Khorsam in Parts I to III of this book, and are so entered in the index.

visited the Kumaun Himālaya and Ngari Khorsum * and laid the foundations of Himālayan stratigraphical geology. He was followed by Dr. F. Stoliczka, whose description and subdivision of the fossiliferous rocks of Spiti [*Memoirs, Geological Survey of India*, Vol. V (1865)]—a valley lying to the north of Kulu—long served as the basis for the classification of the sedimentary rocks of the Tibetan zone. Simultaneously the work of Lieutenant-Colonel Godwin-Austen [*Quarterly Journal, Geological Society*, Vols. XX (1864), XXI (1865), XXII (1866)] and of Verchère [*Journal, Asiatic Society of Bengal*, Vols. XXXV (1866), XXXVI (1867)] proved the extension of this zone into Kashmīr, and the subsequent surveys of Kumaun, Ngari Khorsum and Spiti by Mr. C. L. Griesbach [*Memoirs, Geological Survey of India*, Vol. XXIII (1891)] and of Kashmīr by Mr. R. Lydekker [*Memoirs, Geological Survey of India*, Vol. XXII (1883)], both confirmed and amplified the results of Stoliczka's earlier traverses, whilst the publications of the Geological Survey Department bear witness to the amount of attention that the Tibetan zone has received in recent years. [*Pal. Indica*, Ser. XV, Vols. I to VII; New Series, Vol. II, Mem. 2; Vol. IV, Mem. 3; Vol. V, Mems. 1-3; Vol. VI, Mems. 2 and 4; Vol. XII; Vol. XVI. *Memoirs, Geological Survey of India*, Vol. XXXVI, pts. 1-3]. Although much still remains to be done, and we can hardly claim yet to have advanced beyond the threshold of Himālayan stratigraphical investigation, nevertheless we have obtained sufficient evidence to reveal the striking fact that, throughout almost the whole period covered by that branch of geology known as "Historical Geology"—that is to say, that portion of the geological time-scale determined by the remains of living organisms—what is now the northern slope of the great Himālayan range lay beneath the waters of a sea, which extended over Tibet and stretched at one time to China and at another to the Mediterranean. Throughout almost the whole of this period, the sea-floor continued steadily to subside and thus rendered possible the deposition on it of those thousands of feet of sediments which have now been raised once more into dry land and form part of the highest mountain range in the world.

Correlation of the systems of the Tibetan zone with those of Europe.—This great series of fossiliferous sediments falls into a number of natural subdivisions which are not capable of exact adjustment to those of the European scale. Thus the clear line of division which is found in Europe between the Palæozoic and Mesozoic groups does not exist in the Himālaya, where beds of Permian age pass upwards by perfect gradation into others with Lower Triassic fossils. There is no break in the continuity of the deposits, and it is consequently impossible to define exactly where Palæozoic ends and Mesozoic begins. Similarly, a well-marked break in the Indian deposits may be bridged over by a perfectly continuous sequence in the rocks of Europe, and it has now been found impracticable

*** Zangskar and Ngari Khorsum are spelt as Zaskar and Nari Khorsum in Parts I to III of this book, and are so entered in the index.**

to apply to the one region the nomenclature of the other. Hence the natural groups of the Himālayan sequence must for the most part be recognised as individual units, characterised by names of their own and referable only approximately to European equivalents.

Classification of the deposits of the Tibetan zone.—The most marked break in the Indian stratigraphical sequence occurs at the base of the Tālchir boulder-bed, and this has been adopted by Sir Thomas Holland as a datum line for the classification of all the post-Purāna rocks, the beds found below this break being included in his Dravidian group and those above it in the Aryan group. [T. H. Holland: *Trans. Min. and Geol. Inst. of India*, Vol. I, 48 (1906)]. These two divisions are clearly marked off from one another in the Salt Range and also in Kashmīr, but there is some difficulty in demarcating them exactly in other parts of the Himālaya; and in the present state of our knowledge of Himālayan stratigraphy, the dividing line between the two cannot be rigidly laid down.

The following table shows the subdivisions recognised in the rocks of the Tibetan zone:—

<table>
<tr><th></th><th colspan="3">System or subdivision.</th><th>Approximate European equivalent.</th></tr>
<tr><td rowspan="8">ARYAN GROUP.</td><td colspan="3">KAREWAS of Kashmīr; OSSIFEROUS BEDS of Ngari Khorsum</td><td>Pleistocene.</td></tr>
<tr><td colspan="3">Stratigraphical break.
NUMMULITIC LIMESTONE of Ngari Khorsum; INDUS VALLEY TERTIARIES.</td><td>Tertiary.</td></tr>
<tr><td colspan="3">KAMPA SYSTEM</td><td rowspan="2">Cretaceous.</td></tr>
<tr><td colspan="3">FLYSCH of Ngari Khorsum; CHIKKIM SERIES; GIUMAL SERIES.</td></tr>
<tr><td colspan="3">SPITI SHALES; JURASSIC of Southern Tibet.
KIOTO LIMESTONE.</td><td>Jurassic.</td></tr>
<tr><td colspan="3">LILANG SYSTEM.</td><td>Trias.</td></tr>
<tr><td colspan="3">KULING SYSTEM.</td><td rowspan="2">Permian.</td></tr>
<tr><td>(in Kashmīr)
ZEWAN STAGE.
GANGAMOPTERIS BEDS.
Stratigraphical break.
=PANJĀL VOLCANICS.</td><td>(in Spiti)
Stratigraphical break</td><td rowspan="2">(in Kumaun)
Stratigraphical break.</td></tr>
<tr><td rowspan="4">DRAVIDIAN GROUP.</td><td>FENESTELLA SHALES.
SYRINGOTHYRIS LIMESTONE.</td><td>PO SERIES.
LIPAK SERIES.
} KANĀWĀR SYSTEM.</td><td>Carboniferous.</td></tr>
<tr><td>MUTH SYSTEM.</td><td colspan="2">MUTH SYSTEM.</td><td>Devonian.</td></tr>
<tr><td>UPPER SILURIAN.
LOWER SILURIAN.</td><td colspan="2">Stratigraphical break.</td><td>Silurian.</td></tr>
<tr><td>? CAMBRIAN.</td><td colspan="2">HAIMANTA SYSTEM.</td><td>Cambrian and Pre-Cambrian.</td></tr>
</table>

Tibetan Zone in Spiti and Kumaun (Plates XLIII, XLIV, XLV).

Haimanta system.

Haimanta system.—The Haimanta system was the name given by Mr. C. L. Griesbach [*Memoirs, Geological Survey of India,* Vol. XXIII (1891)] to a series of conglomerates, quartzites and slates found in the Kumaun and Garhwāl Himālaya and immediately overlying the crystalline schists of the Vaikrita system. The passage from the one system into the other is often quite gradual and no hard and fast line can be drawn between the two. This is no doubt due to the fact that the Vaikrita system consists partly of sedimentary beds which have been metamorphosed by the Himālayan granite and which are in all probability merely the altered representatives of the lowest members of the Haimanta system (see above, p. 290). The greatest development of this system is found in the Kumaun and Garhwāl Himālaya, but it is also seen in the mountains to the north of Kulu, in Spiti and in Lahaul. In Spiti, the uppermost beds have yielded trilobites similar to those found in the rocks of the Cambrian system in other parts of the world [H. H. Hayden: *Memoirs, Geological Survey of India,* Vol. XXXVI, pt. 1 (1904)].

Muth system.

Coral limestone and conglomerate.—The beds of the Haimanta system are overlain by a group of beds named by Stoliczka the "Muth series". In Kumaun and Garhwāl the lowest member is a dark coral limestone with imperfect fossils, said to be of Ordovician age; this subdivision is not found in Spiti, the slates with Cambrian trilobites being overlain unconformably by a conglomerate composed of pebbles of the underlying rocks.

Red quartzite.—The next bed, both in the eastern and western sections, is a red quartzite, the colour of which is very persistent and serves as an unfailing guide to the recognition of this subdivision; it contains no determinable fossils, but is overlain by limestone with corals—including the very characteristic species *Halysites catenularia*—trilobites and brachiopods, such as occur in the Silurian rocks of Europe.

Muth quartzite.—Above this is a remarkable band of white quartzite, which is a constant feature in Himālayan sections of this part of the fossiliferous series. It is known as the Muth quartzite, from the village of Muth in Spiti. At its base are some thin bands of darker quartzite containing a brachiopod [*Pentamerus* (?) *oblongus*] probably identical with a species common in the upper part of the Gothlandian of Europe. No fossils have been found in the main mass of the quartzite, which may be of either Gothlandian or Devonian age and probably represents a part of each system.

In the Ordovician section the fauna shows affinities with American rather than with European forms, but in the Silurian this is the case only with the corals,

in the remainder European affinities predominating [F. R. Cowper Reed: *Pal. Indica*, Ser. XV, Vol. XII, Mem. 2 (1912)].

Kanāwār system.

Lipak series: Syringothyris limestone: Po series: Fenestella shales.—In parts of Spiti, but not in the more easterly sections of Kumaun and Garhwāl, the Muth quartzite passes up into a thick series of limestone and shale containing at the base fossils which are possibly of Devonian age, but in its upper beds (the Syringothyris limestone) a rich fauna characteristic of the Lower Carboniferous (Mountain Limestone) of Europe. This is overlain by about 2,000 feet of shale and quartzite containing two important fossiliferous horizons, the lower of which has yielded plant remains and the upper is characterised by great numbers of *Bryozoa*, amongst which the genus *Fenestella* is particularly common: this bed has consequently been named the "Fenestella shales" [H. H. Hayden: *Memoirs, Geological Survey of India*, Vol. XXXVI, pt. 1 (1904)]. It corresponds in age with the Middle Carboniferous of Europe but the fauna has a highly individual character. These two groups of beds, the limestone series and the shale and quartzite, have only been found completely developed in Kashmīr, Spiti and Kanāwār, being absent from Garhwāl and Kumaun. The lower series is very well exposed in the valley of the Lipak river near Lio, a village on the right bank of the Spiti river just above its confluence with the Sutlej; it has consequently been named the Lipak series, whilst the upper beds, the shales and quartzites, are known as the "Po series", after the village of Po in lower Spiti. For convenience of reference the two may be grouped together under the name "Kanāwār system".

Break in continuity of deposits above the Kanāwār system.—The top of the Po series, which corresponds approximately with the end of the Carboniferous period in Europe, marks an important epoch in the stratigraphical history of the Spiti and Kumaun Himālaya. The shales and quartzites pass upwards into conglomerates composed of rolled boulders of limestone, slate, quartzite and granite derived from the erosion of the various older rocks, such as the Po quartzites, Lipak limestones and members of the Haimanta system. It is thus clear that before the deposition of this conglomerate parts of the sea-floor, on which the older systems had been laid down, were raised up to form dry land, which then underwent erosion. Similar conditions prevailed throughout Garhwāl and Kumaun and may have extended even further east, but the whole of the Nepāl, Bhutān and Assam Himālaya is still unsurveyed and we know practically nothing of the geological conditions to the east of Kumaun.

Dothak series in Tibet.—A group of beds, which has been described as the Dothak series [H. H. Hayden: *Memoirs, Geological Survey of India*, Vol. XXXVI, pt. 2 (1907)], at the lower end of the Phari plain, may possibly cover a part of this period, whilst fossils of approximately the same age as those of the Fenestella

shales have been found in rolled boulders in the gorge of the Subansiri in Assam [J. M. Maclaren: *Records, Geological Survey of India,* Vol. XXXI, 186 (1904); C. Diener: *ibid,* Vol. XXXII, 189 (1905)] and thus afford evidence of the presence of fossiliferous beds somewhere in the catchment area of that river, but their relations to such older and younger beds as may be present are completely unknown.

Absence of Kanāwār system from Kumaun.—In the Kumaun and Garhwāl Himālaya the whole of the Po series, as well as the Lipak series, is wanting, and the overlying beds rest usually on an eroded surface of the Muth quartzite or, more rarely, on the underlying limestone. In Spiti and Kanāwār extensive erosion took place throughout the greater part of the area before the deposition of the conglomerate which occurs above the Po series, but at both the upper and lower ends of the Spiti valley, the Lipak series and the Po series have been preserved.

Kuling system.

The next overlying series was first observed in Spiti by Stoliczka, who named it the Kuling series [*Memoirs, Geological Survey of India,* Vol. V, pt. 1 (1865)]. It consists of conglomerate at the base overlain by calcareous sandstone, which is covered in turn by a bed of black shale—about 150 feet thick—known as the "Productus shales" [*Memoirs, Geological Survey of India,* Vol. XXIII, 66 (1891); XXXVI, pt. 1 (1904)] on account of the predominance in it of brachiopods, which were originally referred to that genus. In Kumaun and Garhwāl the presence of the conglomerate and overlying calcareous sandstone has not been recorded, but the Productus shales appear to lie directly on one or other horizon of the older systems. The fossils of the Productus shales are numerous and well preserved, and this horizon, together with the underlying sandstone and conglomerate, is regarded as approximately equivalent to the Permian system of Europe.

Lilang system.

The next overlying beds show a distinct change both in the character of the component rocks as well as in the fauna that they contain; for whereas the predominant elements of the Kuling system are shallow-water coastal deposits, such as conglomerate, sandstone and shale, containing the remains of brachiopods the next group of beds consists chiefly of limestone, deposited for the most part in deeper water beyond the reach of the sand and mud derived from the neighbouring land. The fauna, too, comprises chiefly ammonites, with only a comparatively small percentage of brachiopods. The change, though rapid, is by no means abrupt; marine conditions still prevailed, but the sea-bottom slowly subsided and what was formerly a comparatively shallow-water area now became deeper and further removed from the shore. There was no interruption of continuity of deposition on the sea-floor nor any *sudden* change in the character of the deposits. It is consequently impossible in the Himālaya to draw any

hard line between the top of the Palæozoic group and the base of the Mesozoic, the passage from one to the other being perfectly gradual. The Productus shales pass up into an alternating series of thin bands of shale interbedded with equally thin bands of impure limestone; as the series is followed upwards, the calcareous element increases and the shale disappears and thence there extends to a vertical thickness of over 6,000 feet a perfectly uninterrupted group of deposits of which the predominant rock is limestone, with subordinate bands of shale and sandstone. This vast series of marine sediments comprises representatives of all the members of the Mesozoic group of Europe, which can be readily identified by means of the numerous fossils that they contain. The most important subdivision, both in point of thickness as well as of fossil contents, is the Lilang system, which is over 3,000 feet thick in Spiti and rather less in the Kumaun and Garhwāl Himālaya. The base of this system is regarded as lying immediately above the Productus shales and beneath a thin band of limestone known as the Otoceras zone, so called from the prevailing genus of ammonite found in it. The Otoceras zone shows an admixture of both Permian and Triassic features, and it is considered by M. P. Bonnet [*Comptes Rendus, Academie des Sciences, Paris,* Vol. 170, No. 21, 1372-1374 (May 1920)], by comparison with the similar occurrences in Armenia, that the beds with *Pseudomonotis griesbachi*, between the Ophiceras zone above and the Otoceras zone below, may be taken as the division between the Permian and the Trias. The lower beds of the Lilang system consist of thin bands of limestone and shale, passing upwards into a thick bed of nodular limestone. Part of this latter bed, together with a series of bands of limestone separated by thin partings of shale, represents the Muschelkalk of Europe, whilst the remainder of the Middle Trias, the Ladinic stage of Europe, is represented by shale and limestone containing the characteristic European fossil *Daonella lommeli*. Above this, again, are representatives of the Carnic and Juvavic stages of the Upper Trias (for correlation see below, p. 308). The best sections of the Trias are in Spiti; to the east its divisions, especially the Ladinic and the Carnic, dwindle in thickness and the shales are replaced by thin pure limestones, poor in fossils.

Kioto limestone.

From Spiti eastwards as far as the western frontier of Nepāl, the Zangskar range is usually capped by a great mass of limestone, over 2,000 feet in thickness, which is for the most part unfossiliferous, but the uppermost beds contain a rich Jurassic fauna, whilst those at the base contain bivalves (*Megalodon* and *Dicerocardium*) characteristic of the Upper Trias. The upper part was named by Stoliczka the "Tagling limestone" and the lower the "Para limestone", of which the Tagling was intended to represent the Jurassic, and the Para the Triassic, part. Like most of the other Himālayan formations, however, this limestone mass cannot be subdivided according to the European scale; it

is a well-characterised stratigraphical unit in which it is impossible to say where the Triassic part ends and the Jurassic begins. It is therefore necessary to have a single name for it, and originally in publications of the Geological Survey it was referred to as the "Grey limestone" [A. von Krafft: *Memoirs, Geological Survey of India*, Vol. XXXII, pt. 3 (1902); C. Diener: *Pal. Indica*, Ser. XV, Vol. V, No. 3 (1908)] in which term was included the whole limestone mass between the top of the Quartzite series of the Lilang system and the base of the Spiti shales. Unfortunately the term "Grey limestone" had already been applied to a subdivision of the Nummulitic series in Hazāra [C. S. Middlemiss: *Memoirs, Geological Survey of India*, Vol. XXVI (1896)], and to employ it also for the limestone of Spiti and Kumaun would lead to confusion. The latter might appropriately be called the "Kioto limestone", as it is well seen in the cliffs behind Kioto in upper Spiti. Of its two subdivisions the name Para stage is restricted to the beds containing *Megalodon* and latterly known as the "Megalodon limestone" [H. H. Hayden: *Memoirs, Geological Survey of India*, Vol. XXXVI, pt. 1 (1904); C. Diener: *op. cit.*] whilst the Tagling stage includes all the rest.

All the subordinate stages of the European Trias have been recognised by their fossils, but the perfect continuity from base to summit of the stratigraphical sequence of the Mesozoic group in the Himālaya, where a single mountain-side not infrequently affords a complete section from the Productus shales to the top of the Spiti shales, renders it impossible to define the exact limits corresponding to those of the stages of the European Trias. The classification of the Himālayan sequence is, therefore, based on the natural subdivisions of its component beds which, according to their fossil contents, can be approximately referred to their European equivalents. Such correlation is facilitated by the large number of characteristic European species, particularly of ammonites, found also in the Himālayan Trias. The general resemblance of the fauna of the Trias of the Himālaya to that of the Alps is indeed so great as to lead to the conclusion that during the Triassic epoch, the sea, known as the Tethys, which extended over much of Asia, was continuous with that in which the Trias of the Alps was being laid down, and that thus intercommunication took place between these two areas.

Spiti shales.

In Spiti, as well as in the Garhwāl and Kumaun Himālaya, the steep limestone cliffs (Kioto limestone) of the Zangskar range are usually capped by undulating downs covered with black friable shales. These are known as the Spiti shales and have yielded large numbers of ammonites and belemnites of Upper Jurassic type [F. Stoliczka: *Memoirs, Geological Survey of India*, Vol. V (1865); V. Uhlig: *Pal. Indica*, Ser. XV, Vol. IV (1903)].

Giumal and Chikkim series.

Here and there, resting on the Spiti shales, lie beds of sandstone, occasionally capped by limestone and shale; these are known as the Giumal sandstone, Chikkim limestone, and Chikkim shales, respectively, and have been so named after the villages of Giumal and Chikkim in Spiti; they have yielded few fossils, but such as have been found are of Cretaceous age [F. Stoliczka: *Memoirs, Geological Survey of India,* Vol. V (1865)]. The Giumal sandstone bears Neocomian and Gault fauna, as was shown by Dr. A. Spitz [*Records, Geological Survey of India,* Vol. XLIV, 213 (1914)]. The Cenomanian is missing throughout the Himālaya [G. de P. Cotter: *Records, Geological Survey of India,* Vol. LIX, 405-409 (1927)], as throughout North-Western India, though well developed in Southern India and Tibet.

Classification of the Aryan and Dravidian Systems of the Tibetan Zone in Spiti and Kumaun.

The above short description of the Palæozoic and Mesozoic rocks of the Tibetan zone is based on their development in Spiti and in the mountains of Kumaun and Garhwāl, in which areas they have been studied in greater detail than elsewhere, whilst the sequence from the base of the Haimantas to the Chikkim shales is the most complete and continuous yet observed in any part of the Himālayan region. Even in these areas, however, much still remains to be done, especially in the direction of a detailed study and subdivision of the Kioto limestone, which embraces the uppermost Trias and the greater part of the Jurassic system.

End of marine and beginning of continental phase in the Himālayan area.—The change from limestone to Spiti shales and Giumal sandstone marks the beginning of a new phase in the geological history of the Himālaya and Tibet. The Tethys gradually began to recede, its southern shores crept slowly northwards and areas, which, throughout almost the whole of the Triassic and Lower Jurassic periods, had lain beneath a clear and tranquil sea, were now brought within reach first of mud and silt and then of sand and grit carried down by rivers from the south. Gradually the sea retreated until the northern ranges of the Himālaya and the whole of Tibet became a continental area. During the progress of this change, however, deposition continued for some time in Ladākh, Ngari Khorsum and Central Tibet; the deposits thus formed are of Lower Tertiary age and are partially marine and partially of fresh-water or estuarine origin. The former are found in Tibet and in Zangskar and the latter in the Indus valley in Kashmīr. In Zangskar these Tertiary beds are represented by a mass of nummulitic limestone found at an elevation of 18,500 feet on the peaks above the Singhgi La [T. D. LaTouche: *Records, Geological Survey of India,* Vol. XXI, 160 (1888)] whilst, further east, nummulitic

limestone is said by Mr. Griesbach to overlie the Cretaceous beds in Ngari Khorsum, to the north-east of the Niti Pass [*Memoirs, Geological Survey of India*, Vol. XXIII (1891)]. The Tertiary rocks of the Upper Indus valley and of the more easterly portions of Tibet will be referred to subsequently (*infra*, p. **323**).

None of these beds are younger than Eocene, the oldest subdivision of the Tertiary system, and they thus furnish us with an approximate date for the close of the marine, and the opening of the continental, phase in the history of the Indo-Tibetan area; this date may be placed in the latter part of the Eocene period of the Tertiary epoch. The crustal disturbances which then took place, resulting in the rise of the land and retreat and disappearance of the sea, were accompanied by great volcanic activity, evidences of which are now to be seen in the lava-flows associated with the Tertiary deposits and in the dykes of intrusive rock found cutting through all the older sedimentary deposits.

The annexed table shows the detailed classification of the Aryan and Dravidian rocks of Spiti and Kumaun [A. von Krafft: *General Report, Geological Survey of India*, 1899-1900 (1901); H. H. Hayden: *Memoirs, Geological Survey of India*, Vol. XXXVI, pt. I (1904); C. Diener: *Pal. Indica*, Ser. XV, Vol. V, No. 3 (1908)].

The "Exotic Blocks" of Malla Johar (Plate XLVI).

Before passing on to discuss the development and distribution of the Palæozoic and Mesozoic beds in other parts of the Himālaya, it is necessary to refer to a very peculiar group of detached blocks of limestone and other rocks found in the extreme north of Kumaun on the Indo-Tibetan frontier and beyond in Ngari Khorsum (Hundes). The culminating ridge of the Zangskar range in Malla Johar and the northern slopes of the same range at Chitichun in Ngari Khorsum are composed chiefly of Spiti shales overlain by a sandstone formation (the equivalent of the Giumal sandstone of Spiti) which passes upwards into a series of sandstone and shale (probably of Cretaceous age) exactly resembling the European "Flysch". Overlying these and resting sometimes on the Spiti shales and sometimes on the flysch, and inextricably mixed with, and embedded in, masses of andesite and other basic volcanic rocks, are innumerable blocks of sedimentary rock, varying in size from mere pebbles to masses of many thousand cubic yards in volume. Blocks of limestone, sandstone, Spiti shale and flysch lie scattered through the volcanics with no trace of regularity or arrangement, whilst the jumble becomes the more confused when the fossiliferous character of certain of the blocks reveals the striking fact that almost every stratigraphical horizon from Permian to uppermost Cretaceous finds its representative in one or other individual block. Unfossiliferous blocks prevail, but those which contain fossils have yielded specimens both sufficiently numerous

Group	System	Sedimentary Rocks of the Tibetan Zone in Spiti and Kumaun.	Approximate European equivalents.
Aryan Group.		Nummulitic limestone and volcanics of Kumaun and Ngari Khorsum. "Flysch" of Kumaun and Ngari Khorsum. "Chikkim shales." "Chikkim limestone." "Giumal sandstone" (Gault). "Spiti shales."	Eocene. Cretaceous. Jurassic.
	Kioto limestone.	"Tagling stage." "Para stage" ("Megalodon limestone" at base).	*Rhætic and Dachsteinkalk* (Trias.)
	Lilang system.	"Quartzite series" with *Spirigera maniensis* (Krafft). "Monotis shales" with *Monotis salinaria* (Schlotheim). "Coral limestone" with many corals and *Spiriferina griesbachi* (Bittner). "Juvavites beds" with *Juvavites angulatus* (Diener). "Tropites beds" with *Tropites cf. subbullatus* (Mojsisovics). "Grey shales" with *Joannites cymbiformis* (Wulfen). "Halobia beds" with *Halobia cf. comata* (Bittner). "Daonella limestone" with *Daonella indica* (Bittner). "Daonella shales" with *Daonella lommeli* (Wissman). "Muschelkalk" limestone with *Ptychites rugifer* (Oppel). "Nodular limestone." (Niti limestone). "Hedenstræmia beds" with *Hedenstræmia mojsisovicsi* (Diener). "Meekoceras zone" with *Meekoceras varaha* (Diener). "Ophiceras zone" with *Ophiceras sakuntala* (Diener). Zone of *Pseudomonotis griesbachi*. "Otoceras zone" with *Otoceras woodwardi* (Griesbach).	Trias.: Keuper: *Juvavic.* (*Noric*); *Carnic.* Muschelkalk: *Ladinic.*; *Dinaric.* *Lower Trias.* (Bunter)
	Kuling system.	"Productus shales" with *Xenaspis* and *Cyclolobus* above (Thuringian) and *Marginifera himalayensis* (Diener) below (Saxonian). "Calcareous sandstone" with *Spirifer fasciger* (Keyserling) and *Spirifer marcoui* (Waagen) (Artinskian). Conglomerate, grit and sandstone (Uralian).	Permian.
Dravidian Group.	Kanāwār system.	"Po series" including "Fenestella shales" with *Protoretepora ampla* (Lonsdale) (Moscovian). "Lipak series"; chiefly limestone with *Syringothyris cuspidata* (Martin) above (Dinantian) and *Atrypa aspera* (Schlotheim) below.	Carboniferous. Devonian.
	Muth system.	"Muth quartzite" with *Pentamerus cf. oblongus* (Sowerby) at base. Limestone with trilobites, brachiopods and corals (including *Halysites catenularia* Lamarck). "Red quartzite." Conglomerate in Spiti and coral limestone in Kumaun.	Silurian.
	Haimanta system.	Slate, quartzite and limestone with trilobites. Blue and black slate (weathering bright red), with carbonaceous shales. Slate and quartzite. Conglomerate in Kumaun,—absent from Spiti.	Cambrian and (?) Pre-Cambrian.

and sufficiently well preserved to leave no room for doubt as to the particular horizon to which each belongs. When, however, we compare them with the corresponding horizons of the typical Palæozoic and Mesozoic sequence of Spiti and Kumaun, they are found to show a very marked difference both in their physical character and in the fauna that they contain. The majority of the exotic blocks correspond with the red limestones of the Hallstatt facies in the Alpine region. Those of Lower Triassic and Muschelkalk age have a close faunistic affinity with the corresponding beds of the Spiti-Kumaun facies, from which they differ only lithologically, but in the Carnic stage there is both faunistic and lithological contrast with the Spiti-Kumaun facies, and a strong resemblance to the Mediterranean facies. This is still more marked in the Liassic, those equivalent to the Dachsteinkalk being in a facies of unfossiliferous, white, dolomitic limestone. Thus the curious fact is revealed that in one and the same area, and almost in contact with one another, there are two distinct facies of Permian, Triassic and Jurassic rocks, the one being the typical Spiti-Kumaun facies and the other that of the exotic blocks. The latter, therefore, cannot be merely fragments of the underlying beds which have been brought into their present anomalous position on the top of beds younger than themselves by a simple process of faulting, to which the origin of certain of the European "Klippenzüge" or "blocs exotiques" has been ascribed; but they must have been transported from some other area, where the upper Palæozoic and Mesozoic facies is different to that of the typical Tibetan zone. Such an area may possibly be found to lie to the north, in Ngari Khorsum, which is still a *terra incognita*, but perhaps contains the solution of one of the most interesting problems of Indian stratigraphical geology.

Mode of origin of the exotic blocks.—The invariable association of these exotic blocks with great masses of lava and other volcanic rocks of sub-aërial origin affords a clue to the manner in which they have been transported to their present position. During the great outburst of volcanic activity which took place throughout the northern parts of the Himālaya and in western Tibet in early Tertiary times, these blocks were torn by the disruptive forces from their parent mass and carried on the lava-flows far to the south of their original home. [A. von Krafft: *Memoirs, Geological Survey of India,* Vol. XXXII, pt. 3 (1902). For other literature on the subject of the exotic blocks, see *Records, Geological Survey of India,* Vol. XXVI, 19 (1893); *Denkschr. d. k. Akad Wien.,* LXII, 533 (1895); *Memoirs, Geological Survey of India,* Vol. XXVIII, 1 (1895); *Pal. Indica,* Ser. XV, Vol. I, pt. 3 (1897); Vol. II, pt. 3].

The Tibetan Zone in the Eastern Himālaya (Plate XLVII).

We shall now try to follow the Tibetan zone from the typical areas of Spiti and Kumaun into other parts of the Himālaya. We have already seen that in these two districts the only point of difference in the oldest (Dravidian) group

of the fossiliferous rocks is the absence from Spiti of the Lower Haimanta conglomerate and of the coral limestone which occurs at the base of the Muth system in Kumaun [*Memoirs, Geological Survey of India,* Vol. XXIII (1891); XXXVI, pt. 1 (1904)] and the presence in lower Spiti of an extensive series of beds, the Kanāwār system [*Memoirs, Geological Survey of India,* Vol. XXXVI, pt. 1 (1904)], which has not been found in any part of Kumaun.

The development of the Aryan group is almost identical in the two areas, but in Kumaun the Lilang system is not quite so thick as in Spiti. As the Tibetan zone is followed south-eastwards towards Nepāl, this thinning out of the Lilang system (Trias) is very marked, the total thickness in Byans being only 2,000 feet as compared with over 3,000 feet in Spiti. East of Kumaun practically nothing is known of the Tibetan zone until we reach the northern frontier of Sikkim, where there is a very extensive development of Jurassic beds, which appear to cover almost the whole of this part of Tibet from Sikkim and Bhutān on the south to beyond Lhāsa. The limestones of the Lhonak range, north of Kānchenjunga, and a small group of limestones at the south-eastern edge of the Phari plain, probably represent parts of the Trias and the Lias of Europe, and the hills which run from Kampa Dzong to Tuna contain an interesting group of limestones and shales (Kampa system) of Cretaceous and Lower Tertiary age [*Memoirs, Geological Survey of India,* Vol. XXXVI, pt. 2 (1907)]. The fossiliferous boulders of Permo-Carboniferous age, found near the mouth of the Subansiri river in Assam, have already been referred to (*supra*, p. 302).

Thus we see that little is known of the Tibetan zone to the east of Kumaun, but it is highly probable that Mesozoic rocks (chiefly Spiti shales and other Jurassic beds) run continuously eastwards along the northern frontiers of Nepāl and Bhutān, possibly even as far as the gorge of the Brahmaputra.

Kashmīr and the Western Himālaya (Plate XLVIII).

Returning once more to our central area and proceeding north-westward and westward from Spiti, we find an extensive development of the Tibetan zone in Kashmīr. In the year 1883 Lydekker published an account of the geology of Kashmīr and adjoining territories [*Memoirs, Geological Survey of India,* Vol. XXII (1883)], based on his own surveys and upon the work of previous observers, amongst whom the names of Drew [*The Jummoo and Kashmir territories* (1875)], Godwin-Austen [*Quarterly Journal, Geological Society,* Vol. XV, 221 (1859), XX, 383 (1864), XXI, 492 (1865), XXII, 29 (1866), *Journal, Royal Geographical Society,* XXXI, 30 (1859)], Verchère [*Journal, Asiatic Society of Bengal,* Vol. XXXV, pt. 2 (1866), XXXVI, pt. 2 (1867)] and Stoliczka [*Memoirs, Geological Survey of India,* Vol. V, pt. 1 (1865), pt. 3 (1866)] are conspicuous. This work was completed before detailed surveys of Spiti and Kumaun had

been carried out and his classification of the rock-groups of Kashmīr is on broader lines than that since adopted for the latter areas. He recognised four main systems in the rocks of Kashmīr, viz. (1) "Tertiary", (2) "Zanskar", (3) "Panjāl", and (4) "Crystalline and Metamorphic".

Crystalline rocks and their distribution.—The crystalline and metamorphic rocks, which consist of granite, gneiss and schist, cover the greater part of northern Kashmīr, including Baltistān, and run westwards through Chilas and Gilgit into the mountains of Afghānistān. Towards the east they run through northern Ladākh and probably continue thence through western Tibet (Rudok) and Chumurti into the mountainous regions north of lake Mānasarowar and the head-waters of the Brahmaputra. In eastern Kashmīr they constitute much of the district of Zangskar, sending out a narrow arm south-eastwards through Lahaul to join the similar rocks of the Great Himālayan range between Kulu and Spiti, and thus merging into the crystalline axis of the Himālaya.

In south-west Kashmīr a narrow strip of crystalline rocks runs along the Pīr Panjāl range, forming a narrow tongue protruding from the wider crystalline area of Chamba and the Dhaula Dhār range, which, again, is an offshoot from the crystalline axis of the Himālaya.

The prevailing type amongst the rocks of this series both in Zangskar and in the Pīr Panjāl is the characteristic Himālayan biotite-granite, and these two crystalline areas are the result of the bifurcation of the hitherto unbroken central zone of the Himālaya. The crystalline zone, which crosses the Sutlej, as a single broad band, from east to west, splits up in Kāngra district into two branches, one of which, following the range between Kulu and Spiti, runs through Lahaul into Zangskar, where it ends in the Nun Kun peaks. The other branch, still maintaining much the same trend, passes through the Dhaula Dhār range into the Pīr Panjāl, where it thins out to a narrow strip, separated only by a band, of insignificant width, of pre-Tertiary rocks from the Sub-Himālayan zone of Jammu and the Murree hills.

Between these two branches of the crystalline zone lies a broad area of sedimentary rocks belonging to Lydekker's "Panjāl" and "Zanskar" systems, which correspond approximately with the Dravidian and Aryan groups, whilst along the north-east of the Zangskar branch runs the direct continuation of the Tibetan zone of Spiti. Throughout Kashmīr the sedimentary beds continue north-westwards until they meet the great crystalline complex of Baltistān, Gilgit and Chilas.

"Panjāl" system.—The outermost strip of sedimentary beds, which lies between the Sub-Himālayan zone of Jammu and Murree and the crystalline axis of the Pīr Panjāl range, has been included by Mr. Lydekker partly in his "Zanskar" system and partly in the "Panjāl" system, which latter takes its name from the Pīr Panjāl range.

The "Panjāl" system included a great variety of rocks, all apparently devoid of fossils and consisting of slates, conglomerates and great masses of trap, representing old lava-flows; the slates and conglomerates prevail in the lower part of the system and the traps in the upper. The system completely surrounds the Srīnagar valley and extends thence southwards along the edge of the crystalline zone of Zangskar. On the opposite side of the latter it runs north-west and south-west and is directly continuous with the Tibetan zone of Spiti. Small patches of the same system also occur at the lakes of Pangong and at Changchenmo near the frontier of Tibet.

Revision of Lydekker's work.—The sedimentary rocks of Kashmīr, although highly fossiliferous in certain localities, are, as a rule, much poorer in fossils than those of Spiti and Kumaun; this, combined with the fact that time did not permit him to carry out his work on the detailed scale that has since been possible in Spiti and Kumaun, led Lydekker to work on broad lines and to rely largely on the physical characters of the rocks as a guide to their correlation with one another and with those of adjacent areas. Since the appearance of Lydekker's memoir in 1883, much detailed stratigraphical and paleontological work has been done outside Kashmīr, notably in Kumaun and Spiti; in the Kashmīr valley itself, and the valleys surrounding it, the detailed researches of Mr. C. S. Middlemiss, carried out with his unerring insight into the problems of field-geology, and published with his enviable clarity of exposition and felicity of phrasing, have indicated serious deficiencies and errors in the original description. If one takes into account the size of Kashmīr and the adjacent territories treated of in Lydekker's memoir, and their mountainous and often inhospitable nature, it is not surprising that revision has introduced important modifications in his conclusions.

Lydekker's "Panjāl" and "Zanskar" systems corresponded approximately with the Dravidian and Aryan groups, but they were worked out on broad lithological lines, and consequently all the slates, conglomerates and traps were referred to the "Panjāl" system, and the limestone groups to the overlying "Zanskar". Certain inconsistencies and imperfections in this distribution render it necessary for Lydekker's classification to be superseded by that of Middlemiss. The result of Middlemiss' observations has also been to establish a twofold division of the stratigraphical record, separated by the great accumulation, about 10,000 feet in thickness, of the Panjāl volcanic series. These volcanic deposits represent a time-interval during which revolutionary changes took place from marine sedimentation to volcanic catastrophism on a grand scale, probably to some extent on land. This is indicated by an unconformity which in some sections is present below the Agglomeratic Slate, and by the land conditions which set in during the effusion of the Panjāl trap giving rise to strata bearing a Gondwāna flora, while the close of the revolutionary period saw the re-establishment

of the Tethys sea and the return to marine deposition during Permian and Trias times.

New classification by Middlemiss.—If the Permian age attributed to the lowest of the Gondwāna plant horizons is correct, then the Panjal volcanics and their land conditions were contemporaneous with the unconformity which throughout Spiti, Garhwāl and Kumaun comes below the Productus shales. This break corresponds with the Upper Carboniferous and the beginning of the Permian in Europe. Over the continental areas of Peninsular India, South Africa, Australia, etc., widespread glacial conditions then obtained.

Below the Panjāl volcanics, fossiliferous formations representing the Upper Silurian, and the Lower and Middle Carboniferous have been found, besides great thicknesses of unfossiliferous beds, the age of which can only be inferred.

With and above the volcanics comes a fairly complete sequence of Upper Carboniferous, Permian and Trias. As was expected from its presence in Garhwāl and Spiti, the long-supposed absence of the Upper Trias (Carnic and Noric) is found to be a misconception, although these beds have not yet yielded the beautiful fauna characteristic of the former areas: great thicknesses of limestones still however remain unsearched.

Middlemiss' investigations are published in three principal papers in the *Records of the Geological Survey of India,* [Vol. XXXVII, pt. 4, 286-327 (1909); Vol. XL, pt. 3, 206-260 (1910); Vol. XLI, pt. 2, 115-144 (1911)] and, in collaboration with the late Mr. H. S. Bion, in his memoir [*Palæontologia Indica,* New Series, Vol. XII, (1928)], "The Fauna of the Agglomeratic Slate Series of Kashmīr". He is also the author of a series of Mineral Survey Reports published by the Jammu and Kashmīr Government, dealing with the economic deposits of the State.

The succession established is, in descending order:—

11. Upper Trias.	Later effusions of Panjāl trap.
10. Muschelkalk.	
9. Lower Trias.	
8. Zewan or Middle Permian.	
7. Gangamopteris beds (Lower Gondwānas).	
Main Panjāl trap flows.	Panjāl volcanic series (Moscovian to Artinskian).
Agglomeratic Slate.	
6. Fenestella series (? Middle Carboniferous).	
5. Passage beds.	
4. Syringothyris limestone series (Lower Carboniferous, Dinantian).	
3. Muth quartzite (? Devonian).	
2. Upper Silurian.	
1. Lower Silurian and (?) Cambrian.	

Cambrian to Devonian.—The age of the older Silurian and Cambrian is very speculative. They consist of greywackés, in places metamorphosed by the intrusive granite, and have been followed for many hundreds of feet below the Upper Silurian, forming a great anticline and a parallel syncline to the south-east of the Kashmīr Valley. The fossils indicate a Llandovery age.

The Upper Silurian consists of about a hundred feet of sandy shales, its outcrop winding with the Muth quartzite round the double fold of the older Silurian, and between these two formations. The chief fossils are *Orthidæ*, *Strophomenæ*, corals, and fragments of trilobites.

The Muth quartzite is composed of a thickness of as much as 3,000 feet of granular white rock, very similar to that of Spiti and Kumaun. It is unfossiliferous and therefore its age is uncertain, except in so far as this can be inferred as Devonian from its position between the Upper Silurian and the Lower Carboniferous.

Carboniferous and Permian.—The Syringothyris limestone series was mapped in places by Lydekker as the Kuling system, though it is now proved to be entirely distinct, and to be separated by many miles from any typical Zewan, Permian or Upper Carboniferous (Kuling) outcrops, and divided from them stratigraphically by many thousands of feet of Fenestella shales, Agglomeratic Slate and Panjāl trap. In the normal sequence the Syringothyris limestone is succeeded upwards by passage beds of unfossiliferous sandstones and shales grading into the Fenestella series, which they resemble except in the absence of fossils. The Fenestella series (or Fenestella shales) were, through a misconception of the structure in the Lidar valley [*Records, Geological Survey of India*, Vol. XL, pt. 3, 207-209, 222 (1910)], erroneously included by Lydekker in the Kuling. The series consists of over 2,000 feet of quartzites, with intercalated dark shales showing a rich bryozoon and brachiopod fauna. Both they, the "passage beds" and the Syringothyris limestone are overlapped to the south-east by the Agglomeratic Slate.

Sir Henry Hayden correlated the Fenestella series with his Po series in Spiti, which there underlies the conglomerate believed to be of Tālchir age. This last is again succeeded upwards in Spiti by the "calcareous sandstone" of Hayden, and then follow the Productus shales. He had previously correlated [*Memoirs, Geological Survey of India*, Vol. XXXVI, pt. 1, (1904); *Records, Geological Survey of India*, Vol. XXXVI, pt. 1, 35 (1907)] the beds at the base of the Zewan stage in Kashmīr (*Protoretepora ampla* horizon) with the Fenestella shales of Spiti. This was an error based on Professor Carl Diener's [*Palæontologia Indica*, Ser. XV, Vol. I, pt. 2, *Anthracolithic Fossils of Kashmīr and Spiti* (1899)] description of a mixed lot of fossils, partly from the Fenestella beds and partly from the true Zewan stage, which are in reality separated by the whole thickness of the Agglomeratic Slate and the Panjāl trap.

The Fenestella shales of Spiti may be safely correlated with the Fenestella series of Kashmīr, and the Productus shales of Spiti with those of Kashmīr. The lower part of the Zewan stage of Kashmīr (*Protoretepora* zone) must then find its equivalent in Spiti in the lower portion of the Productus shales, and Hayden's correlation of the Po series must now be understood to be only with the Fenestella series. The great unconformity which extends from Kumaun to Spiti, and which is marked by a conglomerate, may be taken as equivalent to the break in sedimentation represented by the Panjāl volcanics, in which case the Spiti conglomerate will approximate in age to the Tālchir boulder-bed, though the former is not a glacial deposit.

Panjāl volcanic series.—The Panjāl volcanic series comes between the Dravidian and the Aryan groups, filling a gap which elsewhere in India is occupied by an unconformity representing a period of crustal movements.

The Agglomeratic Slate consists of several thousands of feet of greywackés and slates, with, sparsely and irregularly dispersed through it, angular fragments of quartz, porphyry, granite, slate, etc., sometimes of great size. As a rule it is barren of fossils, but in some beds Mr. C. S. Middlemiss and the late Mr. H. S. Bion [*Fauna of the Agglomeratic Slate Series of Kashmīr, Palæontologia Indica,* New Series, XII (1928)] discovered a fauna bridging the gap between the Middle Carboniferous (represented by the Fenestella shales) and the Permian which immediately overlies the Panjāl trap. Two views of its origin have been held; one that it is due to the action of low temperatures, with transport of the frost-riven debris by floating ice-masses, and the other that it is due to paroxysmal vulcanism and subsequent ordinary deposition. The presence of Lower Gondwāna plants in beds immediately overlying the Panjāl trap suggests an analogy with the Tālchir boulder-bed, though none of the boulders have ever been found to be facetted or striated. The volcanic explanation has recently been strongly supported by the discovery by Mr. D. N. Wadia [*The Geology of Poonch State*: *Memoirs, Geological Survey of India,* LI (1928)] of abundant fragments of devitrified glass and felspar phenocrysts. Upwards the Agglomeratic Slate passes into the Panjāl trap, the two often being found interbedded in the passage zone. Between the two, bands of Infra-Trias limestone occur, or may be interbedded with either of the formations, in sections near the acute bend of the syntaxis.

The Panjāl trap consists of as much as five thousand feet of bedded lavas, in flows from a few inches to twenty feet or over in thickness. The individual flows are markedly lenticular, and the formation as a whole may be absent over large areas, only the Agglomeratic Slate representing the volcanic series; conversely the trap may be found alone, without any underlying slate, as if by overlap of the former. The lavas are basalts, very compact in texture, though felspar phenocrysts sometimes occur, and amygdaloidal varieties are common.

They are usually considerably devitrified and silicified, and their characteristic green colour is due to the development of secondary epidote and chlorite.

Age of Panjāl volcanics.—At the base of the Agglomeratic Slate are the Fenestella shales, of lowest Middle Carboniferous (Moscovian) age, but the lowest horizon at which the base appears shows variations due to overlap ; for instance, in the Lidar valley this is upper Moscovian, and in the Nagmarg area upper Uralian. The *Eurydesma* horizon [*Records, Geological Survey of India,* LVIII, preface, i (1931)] has been found in the Bren Spur near Srīnagar, below these Nagmarg beds. The top of the Panjāl trap is still more variable. It forms in places a floor for the Gondwāna Gangamopteris beds, though more usually a little higher—to the base of the marine Zewan beds (Permian), but north-west of Sonāmarg the upper surface of the trap shifts to higher levels in the Permian and north of the Wular Lake appears successively in contact with Lower Trias, Muschelkalk, and Upper Trias.

Permian.—The Gangamopteris beds are a series of sandstones and carbonaceous shales, as much as 800 feet in thickness, with a characteristic Lower Gondwāna flora, and lie directly above the Panjāl traps. They are frequently silicified, from the solfataric activity at the close of the period of vulcanism.

On the Gulābgarh Pass, in the Vihi district of the Kashmīr valley and in the Lidar and Sind valleys, sections of the Zewan Permian beds have been worked out in great detail by Mr. Middlemiss. In certain sections plant-bearing beds are overlain by more trap and ash, in turn followed by a bryozoon limestone with *Camarophoria,* so that it appears that the traps may sometimes extend through the Gangamopteris beds and take the place of the lower part of the Zewan beds.

In other sections the basal Zewan bed, a grey crinoid limestone, lies directly upon the Panjāl trap, or with an intervening layer of " novaculite ", a metasomatic silicification of limestone. Above this the zone of *Protoretepora ampla* follows immediately. On this succeed some 500 feet of shales and thin limestones, with a rich Permian fauna of *Athyris, Productus, Spirifer rajah, Marginifera,* etc.

Trias.—In several of these sections the Trias follows upon the Permian. The *Otoceras* horizon at the base of the Lower Trias was discovered by the late Mr. H. S. Bion [*Records, Geological Survey of India,* Vol. XLIV, pt. 1, 39-40 (1914)], the genus *Productus* rather surprisingly occurring with it. *Ophiceras* and *Meekoceras* horizons are also known and a very full sequence in the Muschelkalk, comparable to that of Spiti, Garhwāl and Kumaun. The presumed representatives of the Upper Trias have yielded no cephalopod fauna, but many brachiopods and lamellibranchs ; great thicknesses of limestones (Lydekker's Supra Kuling) however still remain unsearched and may yet yield some of the beautiful fauna of the Upper Trias in the Central Himālaya. Messrs. Middlemiss [*Records, Geological Survey of India,* Vol. XLIV, pt. 1, 38 (1914)] and

Bion collected certain Jurassic fossils from beds which succeed normally the Upper Trias in the Banihal Pass. The following table summarizes the Trias horizons of Kashmīr :—

Upper Trias. (Many thousands of feet.)	Unfossiliferous massive limestones.	
	Spiriferina stracheyi and *S. haueri* zones.	
	Lamellibranch beds.	
Muschelkalk. (About 900 feet.)	*Ptychites* horizon.	Sandy shales with calcareous layers.
	Ceratites beds.	
	Rhynchonella trinodosi beds.	
	Gymnites and Ceratites beds.	
	Lower nodular limestone and shales.	
	Interbedded thin limestone and shales.	
Lower Trias. (Over 300 feet.)	*Hungarites* shales (position uncertain).	
	Meekoceras limestones and shales.	
	Ophiceras limestones.	

Himālayan re-entrant.—Perhaps the most striking feature of the Himālayas, when either the orographical or the geological map of the range is looked at, is the great re-entrant between Murree and the Kashmīr valley. This is an acute bend which affects both the trend of the mountains and the lie of the geological formations to a depth of some 300 miles, from the foot-hills near Mangla, to beyond the central axis of the Great Himālaya as far north as the foot of the Pāmirs in latitude 37° north. East of the Jhelum river they have the normal Himālayan strike, in a NW.-SE. direction, which remains constant from Assam to Kashmīr, but where they cross the Jhelum they are curved in deep loops, the river being the pivot on which each formation in turn swings. At Muzaffarabād the trend-lines form an almost parallel-sided hairpin bend, but the acuteness of the angle decreases from here outwards towards Mangla, where the angle between the two sides of the flexure is about 120°. Beyond this the strike maintains a NE.-SW. direction for 100 miles at least. The real apex of the re-entrant is, as implied by Sir Henry Hayden [*Records, Geological Survey of India*, Vol. XLV, pt. 4, 321, 325 (1915)], the Pāmirs, and it is the great granite *massif* of the Pāmirs which has acted like a peg in retarding at one place the folds in the sedimentary upper crust as they were pushed against it and around it from the north. An analogy may be drawn to the festooning of a curtain on each side of the point at which it is looped up. This structure is termed a "syntaxis" by Prof. Sollas in his translation of "The Face of the Earth", [Vol. I, 422 (1904)] as a rendering of the German word *Schaarung* used by Suess.

Elements of syntaxis.—It is suggested by Mr. D. N. Wadia [*Memoirs, Geological Survey of India*, Vol. LI, pt. 2 (1928); *Records, Geological Survey of India*, Vol. LXV, pt. 2, 189-220 (1931)] who has worked out the geology of this

complicated area, that the Himālayan system of earth-folds has moulded itself on to a tongue-like projection of the ancient shield of Peninsular India, *i.e.*, Gondwānaland. It is uncertain, and it is immaterial from the point of view of the structure, whether Gondwānaland moved northwards under the folds, or whether the folds came from the north and were piled up on Gondwānaland. Be that as it may, the direction of pressure along a north and south line has been resolved into two components acting on the two sides of the re-entrant.

The area, as will be seen from Mr. Wadia's map (Plate XLVIII) and section (Plate LII, fig. 1), has three well-defined elements :—

1. The *foreland*, a triangular promontory of Gondwānaland, covered almost entirely by Tertiary (Siwālik and Murree) rocks thrown into short, confused folds.
2. The *folded belt*, which wraps round the foreland on its north-west, north and north-east, and consists of formations from the Carboniferous to the Eocene, belonging to the Himālayan geosyncline. These are thrown into recumbent anticlines which are forced over the foreland.
3. The *nappe zone*, which is composed of old unfossiliferous rocks which have been thrust in flat sheets over the newer rocks of the folded belt.

These three elements are divided from each other by two lines of dislocation, which lines form the boundaries of the folded belt. In the outer of these, that between the folded belt and the foreland, the relations are those of a reversed fault, such as the "main boundary fault" already referred to (pp. 281 282), in which the ratio of horizontal to vertical movement is not very considerable. In the inner line, between the folded belt and the crystalline rocks, the upper limb of a disrupted recumbent fold is described by Mr. Wadia as having travelled some miles along an almost horizontal line of thrusting, and the movement of large flat sheets of rock is of the same order as that in the case of the *nappes* of the Alps.

Inwards from the north-western side of the re-entrant lies the country of Hazāra, which has been described by Mr. C. S. Middlemiss (p. 324, Plate XLIX). [*Memoirs, Geological Survey of India,* Vol. XXVI (1896)].

Above the other, north-eastern side, rises the mountain chain of the Pīr Panjāl, which divides the foot-hills of the Jammu State from the valley of Kashmīr. Recent work by Mr. D. N. Wadia [*Memoirs, Geological Survey of India,* Vol. LI, pt. 2, 223 (1928)], on this range has elucidated its structure, and as it is intimately bound up with the re-entrant, its description can best be undertaken by passing onwards from the Siwālik foot-hills towards Kashmīr, although this involves a departure from the usual procedure of describing the older formations before the younger.

Siwāliks and Murrees in the re-entrant.—As has been explained (p. 281) the "main boundary fault" dies out into a fold not far from the mouth of the re-entrant, and the passage between Murrees and Siwāliks becomes transitional. Where faulting between them has taken place, it is a normal dislocation, and not a limit of deposition.

The lithological facies of the Siwāliks departs considerably from the normal elsewhere, and approximates more to that of the underlying Murrees. The Siwāliks here form a natural basin of conformable deposits in a sinking trough of the Murrees.

Amid the sandstone hills of the Murrees the "Great Limestone" occurs as two anticlinal inliers, exposing a great thickness of silicified and dolomitised unfossiliferous limestone. Its age is unknown; it has been attributed to the Kioto limestone (Trias-Jurassic) and to the "Infra-Trias", but without definite evidence.

Eocene of re-entrant and Pīr Panjāl.—Along with the "Great Limestone" of the inliers, Eocene beds of the newer Subāthu facies (Lower Kirthar and Upper Laki) are associated, overlying the "Great Limestone" unconformably. Resting on the gently inclined dip-slopes of the "Great Limestone" are beds of bauxitic laterite derived from the desilicification of basal Eocene clays, the freed silica having locally impregnated the top of the "Great Limestone". Between the base and the white nummulitic limestone which here forms the greater part of the Eocene, the shales contain some lenticular coals. Dykes of peridotite, altered to serpentine, intrude the "Great Limestone" and the bauxitic and coaly beds, but do not pass into the nummulitic limestone.

Between the two lines of thrusting which delimit the "folded belt", the Panjāl volcanics form the core of the great recumbent anticline of Eocene rocks and, before folding took place, were the floor upon which these were deposited.

In the main recumbent fold the Trias is only fragmentarily developed in faulted strips, and that in its poorly fossiliferous facies of Hazāra. Near Uri it is underlain by small crushed masses of Permian (Zewan) limestone.

A persistent band, 100-150 feet thick, of a vivid orange colour, conformably underlying the Eocene, into the contorted white limestones of which it is infolded, represents the Giumal and Spiti shale horizons (Argovian to Gault).

Next to the Panjāl volcanics, the Eocene is the most important unit on the south-west flank of the Pīr Panjāl. For some seventy miles along the strike, and for a breadth of two or three miles, it constitutes a line of ranges and spurs which rise precipitously to elevations of 8,000 to 11,000 feet, from among the hills of Murree rocks, which do not often exceed 5,000 feet.

Lydekker termed the lower massive limestones "Supra-Kuling" and the upper, variegated shales "Kuling", attributing to them Triassic and Carboniferous ages respectively.

Major H. H. Godwin-Austen [*Quarterly Journal, Geological Society*, Vol. XX, 383] suggested in 1864 that they were Nummulitic, and Sir Edwin Pascoe [*Memoirs, Geological Survey of India*, Vol. XL, 439, 450] in 1920 emphatically endorsed this. The discovery of *Assilina* and *Operculina* associated with *Ostraea* has now established this, but the occurrence of *Fusulina* as well points to the emergence of Carboniferous rocks somewhere.

The Eocene of the syntaxis consists of about 1,500 feet of strata, distributed as follows :—

Murree series.

—.—.—.—.—.—.—.—.— *Thrust plane.* —.—.—.—.—.—.—.—

Upper Nummulitic variegated shales, unfossiliferous	500-900 feet.
Lower Nummulitic calcareous shales, bituminous limestone ('Hill Limestone')	500 feet.
Coaly and pyritous shales, lenticular quartzites	....
Grey limestone, unfossiliferous (age uncertain)	200-400 feet.

—.—.—.—.—.—.—.—.— *Unconformity* $\frac{or}{and}$ *fault.*

Panjāl volcanics, Trias, etc.

Geology of the Pīr Panjāl.—The *nappe* zone coincides more or less with the range of the Pīr Panjāl. The rocks which are included in it are principally unfossiliferous pre-Cambrian or older Palæozoic, with the Panjāl volcanics. The Palæozoic and Mesozoic sedimentary basins of Kashmīr, worked out by Middlemiss and Bion, and that of Shamsh Abari worked out by Wadia, lie in synclinal depressions of this complex.

It may be stated that the broad belt of granitic gneiss which is shown by Lydekker as running along the central axis of the Pīr Panjāl does not exist, only disconnected bosses of gabbro being present. These are intrusive in the Panjāl volcanics and are associated with thick sills of dolerite in the Agglomeratic Slate, and dykes of lamprophyre in the Dogra slates. Far remote from the axis of the Pīr Panjāl bosses and veins of gneissic granite do occur as intrusions in the Dogra slates and the Gondwānas. These are similar to the gneiss or granite of Chamba and Hazāra, coarsely granitoid in the centres of the bosses, becoming schistose on their margins and merging into the slates by *lit-par-lit* injection. On the same line of strike, but a considerable distance away, are sills of rhyolite and orthoclase-porphyry.

The sedimentary rocks of the Pīr Panjāl were included by Lydekker in his "Panjāl system", an immense thickness of slates and traps. This has now been divided into (*a*) the Salkhala series and the Dogra slates, (*b*) a sequence of six divisions of Palæozoic sediments ranging from the Cambrian (?) and Lower Silurian to Middle Carboniferous (p. 313) and (*c*) the Panjāl volcanics, comprising the Agglomeratic Slate and the Panjāl traps.

In addition to the Panjāl traps, there are included in Lydekker's "Panjāl system" much older chloritised traps belonging to the Dogra slates; these traps

are both amygdaloidal, contemporaneous lavas, (now converted into schists) and intrusive dykes.

Attock or Dogra slates.—The term "Dogra slates" has been proposed by Mr. D. N. Wadia [*Memoirs, Geological Survey of India*, Vol. LI, pt. 2, 227 (1928)] in substitution for Lydekker's "Panjāl slates", a name which he unfortunately used to cover the "Agglomeratic Slate" series as well, and which ought accordingly be allowed to lapse.

The Salkhala series occurs below the Dogra slates. The essential difference between them is the occurrence of quartzite, marble and graphite in the Salkhala series. Otherwise they are monotonous assemblages of slates, often carbonaceous, pyritic or calcareous, phyllites and calc-, chlorite-, talc- and sericite-schists. A greater degree of plication, granite intrusion and metamorphism characterises the Salkhalas. The contact between them is usually a thrust-plane, but two sections of an apparently conformable passage have been seen by Mr. Wadia [*Records, Geological Survey of India*, Vol. LXV, pt. 2, 197, 202 (1931)].

The Dogra and Salkhala formations were included in the Hazāra slate series of Middlemiss, and the Attock slates of Wynne (1872), and they may be the same as the Simla slates and the Jutogh series of the Simla hills. As the term "Attock slates" has priority of usage, it is likely to be ultimately adopted. The correlation of these unfossiliferous and monotonously argillaceous series must ever be fraught with difficulty, and their stratigraphical position is no help, for along their south-western boundary they rest upon the Eocene along a thrust-plane, while their inner limit lies unconformably below the Gondwānas or Agglomeratic Slate. Further complication and uncertainty are introduced by the fact that in some sections on the east of the syntaxis a conformable passage can be traced from the Dogra slates into the older Palæozoic (Cambro-Silurian) rocks developed in the Shamsh Abari syncline (p. 322) and the valley of Kashmīr (p. 314). These contain sparse and obscure gastropods, trilobites and brachiopods. They are succeeded by the Muth quartzite (Devonian) which is recognised by its lithological character.

Tanāwal (Tanol) series.—Also infolded with the Dogra slates, are elongated outcrops of arenaceous schists and quartzite, which by Messrs. A. B. Wynne [*Records, Geological Survey of India*, Vol. XII, 122 (1879)] and C. S. Middlemiss [*Memoirs, Geological Survey of India*, Vol. XXVI, 236-239 (1896)] were termed the Tanāwal (Tanol) series. They are unfossiliferous rocks, attaining much the same grade of metamorphism as the Dogra slates, and in places are extensively injected by granite veins. Though much more quartzose in their composition than the Dogra slates, and in some localities having a conglomerate at their base, there is often difficulty in drawing a boundary between the two formations. Many of the quartzites are silicified limestones [*Records, Geological*

Survey of India, Vol. LXV, pt. 2, 204, 205 (1931)] and some of the conglomerates may be autoclastic. There is no definite evidence as to the age of the Tanāwal series.

Infra-Trias.—Another group of doubtful age is the "Infra-Trias" of Messrs. A. B. Wynne [*Records, Geological Survey of India,* Vol. XII, 124 (1879)] and C. S. Middlemiss [*Memoirs, Geological Survey of India,* Vol. XXVI, 17 (1896)]. This consists principally of unfossiliferous limestones, with a conglomerate at their base, in which Mr. D. N. Wadia [*Records, Geological Survey of India,* Vol. LXV, pt. 2, 207 (1931)] discovered ice-scratched boulders. This suggests a correlation with the Blaini boulder-bed and the Tālchir boulder conglomerate of the Salt Range. Generally speaking, the "Infra-Trias" is associated with the Panjāl volcanics in the "folded belt", or extends into the "foreland", if the "Great Limestone" occurring as anticlinal outliers amidst the Murrees is taken to be Infra-Trias in age. This, however, is uncertain. Mr. Wadia (*ibid.* p. 208) mentions sections in which the Infra-Trias underlies and is interbedded with the Panjāl traps. This, and the correlation of the boulder-beds, would indicate an uppermost Carboniferous to Lower Permian age for the Infra-Trias, but in default of fossil evidence, the question must be regarded as uncertain.

Palæozoics of Shamsh Abari range.—In the Shamsh Abari range dividing the catchment area of the Jhelum from that of the Kishanganga, Mr. D. N. Wadia discovered a synclinal basin of Palæozoic sediments, in the midst of granite-intruded slates and schists. A conformable sequence can be made out from the Salkhala series of Pre-Cambrian sediments through a great thickness of unfossiliferous Dogra slates, to a group of slates, quartzites and limestones, about 6,000 feet thick, which contain trilobites and brachiopods ranging from the Cambrian to the Silurian. These are succeeded by about 2,000 feet of the Muth quartzite (Devonian), and then by 150 feet of local representatives of the Syringothyris limestone. On this follows the Panjāl volcanic series, over 5,000 feet in thickness, overlain in the axis of the syncline by some hundreds of feet of Triassic limestones.

Geological history of Pīr Panjāl, Hazāra and Kashmīr.—On the south-west of the Pīr Panjāl there is a great stratigraphical break between the Purānas and the fossiliferous Permian at the base of the Aryan group, partly occupied by the Agglomeratic Slate and the Panjāl Traps of Middle to Upper Carboniferous age. In Kashmīr proper this is bridged over by a development of the Silurian, Devonian, and Carboniferous. From the Middle Carboniferous the Panjāl area became a part of the Kashmīr geological province, and from then to the end of the Trias there is a close similarity between the formations of both areas. In Hazāra the unconformity is shown by a great hiatus between the Purāna Hazāra slates and the Infra-Trias, the age of which is not known but which may be Permo-Carboniferous.

The Carboniferous, Permian and Trias are distinct in Hazāra and the Pīr Panjāl. Up to the end of the Dravidian era these two provinces appear to have been land areas, but deposition was resumed with the Agglomeratic Slate in the Pīr Panjāl under alternate land and sea conditions, and with the Infra-Trias in Hazāra under more entirely marine conditions. Henceforth these two provinces became isolated from each other, until the beginning of the Eocene. With the Agglomeratic Slate period the Pīr Panjāl became part of Kashmīr and deposition continued until the uppermost Trias, although in the Pīr Panjāl it is represented only by patches of Middle and Upper Permian and Upper Trias limestones. The Pīr Panjāl formed the southern limit of the marine Trias of the Himālaya and this thinning-out shows the coast of the Tethys of that time. Except for the orange band (p. 319) representing the Giumal and Spiti horizons (Argovian to Gault) and the beds containing Jurassic fossils at the top of the Banihal Pass section (p. 317), Jurassic and Cretaceous are absent from Kashmīr and the Pīr Panjāl ; in Hazāra, on the other hand, these two systems are widely, though thinly, developed, in close association with the Eocene. In the Pīr Panjāl this Trias-Eocene break is the second great unconformity, and marks the final severance of the area lying to the north of the Pīr Panjāl, and the restoration of physical continuity between the areas to the south of it from the Eocene onwards.

Indus valley Tertiaries.—Although the subdivision of the Himālaya into three zones, the Sub-Himālayan, Himālayan and Tibetan, which is so well marked eastwards of the Beās, is not so clearly defined in Kashmīr where the crystalline rocks invade both the Tibetan and Himālayan zones, yet the outer, or sub-Himālayan, zone is clearly marked off and can be traced through Jammu into the Murree hills and the gorges of the Jhelum. This zone of Tertiary rocks has already been described above, but there remains a group of beds also of Tertiary age, to which reference has been made in connection with the Tibetan zone. These are the Indus valley Tertiaries, which extend as a long narrow strip in the valley of that river from eastern Ladākh to Kargil. They are apparently quite unconnected with the Tertiaries of the Sub-Himālayan zone, and consist of conglomerates, sandstones and shales of fresh-water origin overlain by limestone with nummulites, which latter, it has already been seen, extends as far south as the Singhgi La in Zangskar (*supra*, p. 306). With these Tertiary beds are associated great masses of volcanic rock, chiefly ashes and lava-flows.

Nummulitic limestone of Zangskar.—The deposition of the nummulitic limestone seems to have been the final chapter in the marine history of the Himālaya and Tibet. With the outburst of volcanic activity the present or continental phase became established, and what had, for a lapse of time which must be counted in millions of years, been more or less continuously the floor of a great sea was now gradually raised up to form the highest mountain range on the face of the globe.

Hazāra (Plate XLIX).

With the exception of Hazāra, very little is known of the geology of the great belt of mountains which extends westwards and north-westwards from Kashmīr. We have already seen that in Kashmīr the regularity of arrangement of the rocks, which to the east of the Beās fall readily into three zones, an outer or Sub-Himālayan, a central or Himālayan and an inner or Tibetan, has disappeared and although the outer zone of Tertiary rocks still persists through Jammu into the Murree hills, the Himālayan and Tibetan zones cannot at present be completely separated from one another. In Hazāra the fusion of the three zones becomes even more complete; the Sub-Himālayan is no longer separated from the Tibetan by the Himālayan and crystalline rocks, but the two are in direct contact and the lowest member of the Tertiary system is intimately infolded with the Tibetan facies of the Triassic, Jurassic and Cretaceous systems, whilst the latter are also found in association with a great series of unfossiliferous slates, which is regarded as the equivalent of the Himālayan zone as developed east of the Beās.

Change in the trend of the mountain ranges consequent on change of strikes of their component beds.—Concurrently with this change in the order of distribution of the three zones, the strike or trend of the rocks, which from Nepāl to the Jhelum is on the whole SE.-NW., changes in Kashmīr and bends round through E.-W. to NE.-SW. Consequent on this the mountain ranges also undergo a similar change of trend, and in Hazāra run approximately from north-east to south-west. Nor is this bending of the ranges confined to the Himālayan chains, but is also reflected in the distant Salt Range of the Punjab.

The rock groups of Hazāra.—The rocks of Hazāra have been subdivided into seven series [C. S. Middlemiss: *Memoirs, Geological Survey of India,* Vol. XXVI (1896)], known as the Crystalline, the Slate series, the Infra-Trias, the Triassic, the Jurassic, the Cretaceous and the Tertiary. These form more or less parallel bands, with the youngest in the outer hills to the extreme south-east. The upper part of the Tertiary system of Hazāra is merely the south-westerly continuation of the Murree beds; the lower portion or nummulitic series, consists of limestone, shale and sandstone with a band of coal. This series covers the greater part of south-east Hazāra, but where it has been removed by denudation the underlying beds of the Mesozoic group have been exposed. These represent the Upper Triassic, Jurassic and Cretaceous systems and include formations such as the Spiti shales and Giumal sandstone, typical of the Tibetan zone.

Infra-Trias and Slate series.—Beneath the Triassic beds is a series of rocks composed of limestone underlain by sandstone and shales which have a thick bed of conglomerate at their base. This is known as the Infra-Trias. It lies unconformably on a great group of unfossiliferous slates, the Slate series, which runs from north-east to south-west through the centre of Hazāra. These

slates, also known as the Attock slates, are probably the equivalent of the Simla slates of the Himālayan zone and of the Dogra slates of Kashmīr and Jammu. The Infra-Trias series was regarded by Mr. Middlemiss as the equivalent of the Blaini series of Simla, and it is therefore probable that the Slate series and the Infra-Trias represent the old sedimentary beds of the Himālayan zone. Behind this, and forming most of north-western and northern Hazāra, is a broad zone of granitic and crystalline rocks, the south-eastern portion of which consists of schists and gneisses, which may be partly Archæan but are to a great extent metamorphosed representatives of the Slate series and the Infra-Trias, which have been altered by contact with granite. The granite of this zone is the exact counterpart of the biotite-granite of the Himālaya, and we thus see in the crystalline zone the representatives of the Vaikrita system and the gneissic granite of the Himālayan zone. The great mountainous area lying between Northern Hazāra and Northern Kashmīr (Baltistān) on the one side and the Hindu Kush in longitude 70° on the other, is still almost completely unsurveyed and deductions as to the geological conditions prevailing in that area can only be drawn from the few scattered observations which have been made in Gilgit and Chitrāl. The prevailing rocks appear to be granite and crystalline schists, but slates, quartzites and limestones, possibly representing the Dravidian members of the Tibetan zone [C. A. McMahon: *Quarterly Journal, Geological Society,* Vol. LVI, 337 (1909)], occur in Hunza and Nagar, whilst beds of Devonian age have been found in the valley of the Kunar river in Chitrāl [C. A. McMahon and W. H. Hudleston: *Geological Magazine,* Dec. IV, Vol. IX, 3, 49 (1902)] and also on the Baroghil Pass [H. H. Hayden: *Memoirs, Geological Survey of India,* Vol. XXXVI, pt. 1, 31 (1904)] between Chitrāl and Wakhan. These rocks appear to strike towards the north-east and may possibly be connected with the fossiliferous series of Palæozoic age found by Stoliczka in the Little Pāmir and Yārkand, and thus serve as a link between the Tibetan zone of the Himālaya and the sedimentary rocks of the Tien Shan.

Afghānistān.

Although Afghānistān, like Tibet, lies beyond the Himālaya, it has been thought fitting to include a short outline of its geology, compiled from Dr. C. L. Griesbach's [*Records, Geological Survey of India,* Vols. XVIII, XIX, XX and XXV (1880 to 1888)], Sir Henry Hayden's [*Memoirs, Geological Survey of India,* Vol. XXXIX, part 1 (1911)], and Dr. Emil Trinkler's [*Afghanistan, Petermann's Mitteilungen,* No. 196 (1928)] works.

The country is divided by the Koh-i-Bāba and the Paghman ranges into two stratigraphical provinces, one of which is confined to eastern Afghānistān and has affinities with the Himālayas, while the other comprises much of the remainder of the country, especially the northern and western districts; the latter is more nearly related to western Asia and Europe. The separation of

the two provinces seems to have taken place towards the end of the Carboniferous.

The eastern facies, near Kābul and Jalālābād, comprises schists and crystalline limestones, the latter containing rubies. These resemble Archæan types but are intimately associated with Palæozoic sediments and may be of older Palæozoic age. They are overlain unconformably by limestones (the Khingil series) which range from the Carboniferous to the top of the Trias.

In the area of the northern facies seen in Bamian and Saighan, the oldest rocks appear to be schists, slates and conglomerates (the Kalu series). These are overlain by a hematite bed and the Hajigak limestone, probably of Devonian and Upper Carboniferous age. Above these are the slates and quartzites of the Helmand series, the relationships of which are very obscure. Above these is a Fusulina limestone of Permian age. The limestone is covered unconformably by the volcanic Doab series, which is probably partly Triassic and partly Jurassic; this passes up into the Saighan series of Jurassic freshwater deposits with some coal-seams [C. L. Griesbach: *Records, Geological Survey of India,* Vol. XX, 93 (1887)], and these again into the Red Grit series of Lower Cretaceous age. Cretaceous limestone, dating from the great Cenomanian transgression is widespread and covers the Red Grit series and all older formations unconformably; it passes up into shales with gypsum, tentatively referred to the Eocene. Last come typical Siwāliks and other Tertiaries.

The general strike of the formations is NE.-SW., curving to NW.-SE. in the east, and the beds are highly folded, the prevailing tectonic elements being reversed folds with crests leaning over to the south-west. The axis of the Hindu Kush is of granite, and intrusive serpentine forms important masses in numerous localities.

Neither the volcanic series nor the overlying Jurassic beds resemble any of the Mesozoic systems of the Himālaya, but are, on the other hand, apparently identical with the Mesozoic beds of Russian Turkistān [J. B. Mushketoff: *Turkistān* (1886, 1906); G. Romanowski: *Geology of Turkistān* (1880-1890)]; hence during part of the Triassic and Jurassic periods these two areas formed a continuous land surface, and probably constituted the south-western coast of the Tethys. Above the Jurassic plant-bearing series is the mass of red conglomerate and sandstone, which is, however, only locally preserved, having been as a rule removed by denudation before the deposition of the next overlying rock group, the Upper Cretaceous limestone. The latter extends all over Northern Afghānistān and is almost always markedly unconformable to underlying beds, a feature which indicates a great extension of the Tethys in later Cretaceous times, when the whole of Northern Afghānistān once more became submerged. This marine phase, however, was of only short duration, for evidence of the drying up of the sea is found in the beds of gypsum and rock-salt occurring in the older Tertiary rocks. Subsequently land plants and land

shells appear, and all the great valleys of Eastern Afghānistān are now filled with deposits of sand and boulders analogous to, and possibly contemporaneous with the Siwālik series of the outer Himālaya.

TIBET.

The foundations of our geological knowledge of Tibet were laid by the late Sir Henry Hayden [*Geclogy of Tsang and U in Central Tibet, Memoirs, Geological Survey of India*, Vol. XXXVI, pt. 2 (1907)], who accompanied the Tibet Frontier Commission of 1903-1904, and, apart from the somewhat restricted observations along the line of march between Chumbi and Lhāsa of the subsequent military expedition, was able to make a detailed examination of the neighbourhood of Kampa Dzong. During the year preceding his death in 1923, he again visited Tibet at the request of the Tibetan Government and carried out a reconnaissance survey of the country to the north-west of Lhāsa. Unfortunately he left no geological map nor written account of his scientific results, but a summary of his field notes has been made by Sir Edwin Pascoe [*Records, Geological Survey of India*, Vol. LIX, pt. 1, 18-19 (1926)].

Though Sir Sven Hedin is not himself a geologist, his extensive collections have been worked out by Dr. Anders Hennig [*Southern Tibet*, Vol. 5, 198-212 (Trans-Himālaya and South-West Tibet)] and Dr. Bror Asklund [*op. cit.*, Vol. 9, pt. 3, Chaps. 1-5 (Eastern Pāmirs)]. During the Mount Everest Reconnaissance Expedition in 1921, Dr. A. M. Heron was able to survey an area to the west of Sir Henry Hayden's, between the Tsangpo and the Himālaya [*Records, Geological Survey of India*, Vol. LIV, pt. 2, 215-234 (1922)].

Dr. E. Trinkler's work "Tibet", in German, published in 1922, gives an account of the geology of the whole country, partly from his own researches and partly from those of other explorers.

Tibet may be briefly described as the Brahmaputra (Tsangpo) valley and a great elevated area of internal drainage dotted with lakes, which taken together are bounded on the north by the range of the Kunlun, and on the south by the Himālaya. To the west the great mountain complex of the Karakorum lies in the angle between these two ranges, and to the east they approach each other and bend southwards into the meridional chains of Indo-China, Burma and Malaya. To the north of the Kunlun lies the Takla Makān desert and the Tārīm basin, with the Tien Shan range to the north again.

The Kunlun.—The Kunlun is much older than the Himālaya, having been already a mountain range in the Palæozoic. It is composed essentially of Devonian limestones and slates, with Carboniferous limestone in minor amount, nearly everywhere metamorphosed by granite and syenite intruded during the folding, which was probably related to the Hercynian movements in Europe. The sea had already receded considerably from the mountains at that period, and with the exception of some Permian and Trias, younger marine beds are

absent, but later continental formations are preserved in longitudinal valleys and basins. Such are the breccias and red sandstones of the Angara and Hanhai formations, which are widely distributed throughout the range, but especially in the low ground at the foot of the mountains. Tertiary deformations have but little altered the form which the Kunlun had assumed at the end of the Palæozoic, and young eruptives, such as andesite, are intruded at only few places through the continental deposits. Bonvalot and Littledale have doubtfully seen active volcanoes from afar.

Central Tibet.—In the plateau lake area of central Tibet, formations older than the Upper Jurassic have not been recognised with certainty. The Spiti shales (Upper Jurassic and base of Neocomian) consisting of sandstone and slates, are overlain by a sandstone, which may be correlated with the Giumal sandstone (Upper Neocomian and Gault) of the Himālaya. North of the ranges of southern Tibet, however, these Upper Jurassic and Lower Cretaceous rocks seldom appear on the surface, being generally overlain by Cenomanian limestones. It appears that this Cenomanian transgression did not extend as far as the Kunlun, where the limestone is missing, as is also the case to the east. Locally above the Cretaceous occur sandstones and conglomerates, continental formations which are much involved in the folding of the ranges of southern Tibet, and are, according to Hennig, post-Eocene Tertiaries. Still younger sediments, with mammalian remains, which Hennig ascribes to the Pleistocene, are present as horizontal conglomerates. Eruptive rocks are scarcer in the area of enclosed drainage than in the ranges of southern Tibet, where they have been forced to the surface in the folding of the mountains. The further south we go, the commoner they become, as granite, and eruptives such as rhyolite, trachyte, andesite and basalt. Between the Tang-ra Tso and the Nyenchen-tang-lha range Hayden [*Pal. Indica*, New Series, Vol. XVI, 36 (1930)] encountered a grit series not unlike the Gondwānas, and a limestone of Permo-Carboniferous (Uralian) age. Some patches of Tertiary strata were noted, one containing some impure coal, and another was a fine dome with a vein of asphalt. The Nyenchen-tang-lha range was found by Hayden to consist of granite, and between it and Lhāsa he passed over great spreads of rhyolite unconformably overlying quartzite and shale. The folding appears to have ceased about the end of the Pliocene.

On the high plains of Tibet, the Spiti shales are very widely distributed but largely covered by Cretaceous limestones. These consist of :—

Post-Eocene (?) sandy slate.
Cenomanian with *Præradiolites hedini*, Douv.
Gault with *Orbitolina subconcava* and *O. bulgarica*
Upper Barremian or Lower Aptian with *O. bulgarica* (forma A) and *O. cf. discoidea* (forma B).
Barremian with *O. conulus* (forma A) and *Choffatella* sp.
Neocomian (?) sandstone.
Spiti shales (Jurassic).

The Giri limestone of Hayden may perhaps have a general correspondence with the Barremian (Neocomian) limestones mentioned above, and the Chikkim limestone of Spiti (Upper Cretaceous in part) with the Cenomanian limestone. [*Records, Geological Survey of India*, Vol. XLIV, 213 (1914)]. Nummulitic (Eocene) limestone has long been known from the upper Indus valley, Zangskar and Hundes, and remnants of it occur in central Tibet, but it appears to be absent from south-western and southern Tibet, though Lower Eocene limestones were found by Sir Henry Hayden.

Southern Tibet.—In that portion of Tibet which lies between the Tsangpo and the main range of the Himālaya, south of Lhāsa and Shigatze, we are on surer ground, thanks to Sir Henry Hayden's detailed work. The underlying rocks, and presumably the oldest, are the crystallines of the main range, banded biotite-gneiss usually garnetiferous, intimately injected with tourmaline-muscovite-pegmatite, to such an extent that the latter is often the predominant rock. Deep down in the valleys near the Tibet-Nepāl frontier are bodies of biotite-schist resembling the Daling series of Sikkim. The banded gneiss is in part a composite-gneiss formed by the injection of this biotite-schist by granite magma, and is in part foliated granite. It is at present uncertain whether this schist is Pre-Cambrian, belonging to the edge of Gondwānaland, or whether it represents highly metamorphosed Palæozoic or Mesozoic sediments, deposited in the Tethys. It is also unknown how much of the granite is the usual Tertiary intrusive and how much is perhaps Pre-Cambrian, but these problems and that of the relation of the gneiss and schist to the overlying metamorphics are not necessarily insoluble, for excellent sections are obtainable in Sikkim and the deep valleys which run down from Tibet to Nepāl.

In the neighbourhood of Mount Everest, the metamorphic rocks which overlie the gneiss have low northward dips and their field relationships show that they pass in the direction of the dip into the folded Jurassic and older rocks of Tibet. They are quartzites and mica-schists, calc-schists and crystalline limestones, and their metamorphism is related to intrusions of the tourmaline-muscovite-pegmatite. Heron found *Spirifer* and *Productus* at the top of the thick limestones which underlie the Spiti shales. This indicates a Permian age for the limestones, if the section is a straightforward one. In the range between Tibet and Sikkim, Sir Joseph Hooker [*Himalayan Journals*, II, 177 (1854)] and Professor E. J. Garwood [in D. W. Freshfield's *Round Kangchenjunga*] found metamorphosed limestones and quartzites, which Hayden [*Memoirs, Geological Survey of India*, Vol. XXXVI, pt. 2, 24 (1907)] tentatively classified as Jurassic or Triassic, but which are proved by typical Productus shales fossils subsequently sent to the Geological Survey of India, to be Permian in part. Prof. G. O. Dyhrenfurth [*Himalaya*, 293-311 (Berlin, 1931)] claims that the

entire Mesozoic is included, though fossils are absent, partly from lithological similarities with the Alpine Mesozoics. He also believes that the succession is inverted on the Jonsong peak, forming a true *nappe* thrust over the biotite-schists. We know that the Trias of Spiti thins towards the east, and Hayden believed that it was represented in the Dothak series south and east of Phari.

The Jurassic covers more of southern Tibet than any other formation, and is represented by the Spiti shales, which comprise the Upper Jurassic. Near Phari and Kampa Dzong they are underlain by a fossiliferous limestone (Lower Oolite), succeeded downwards by a crinoid limestone and a brachiopod limestone, divided by slates and quartzites; these are included in the Lias. Above the Spiti shales is an extensive series of fossiliferous Cretaceous and Eocene limestones (the Kampa system), which are folded into the Spiti shales as isoclines. The fauna has been worked out by Mons. H. Douvillé [*Palæontologia Indica*, New Series, Vol. V, Mem. 3 (1916)], and his conclusions modified in a paper by Dr. G. de P. Cotter [*Records, Geological Survey of India*, Vol. LIX, pt. 4, 410-418 (1927)] who shows that his Danian is really Eocene.

The following table gives the revised correlation :—

Eocene	Dzongbuk shales. Alveolina limestone. Orbitolites limestone. Spondylus shales. Operculina limestone. Gastropod limestone. Ferruginous sandstone.
Maestrichtian	Tuna limestone.
Campanian	Third scarp limestone. Second scarp limestone.
Emscherian	First scarp limestone.
Turonian	Hemiaster shales.
Cenomanian	Kampa ammonite shales.
Lower Cretaceous	Giri limestone.
Upper and Middle Jurassic	Spiti shales.
Lower Oolite	Lungma limestone.
Lias	Slate and quartzite. Crinoid limestone. Slate and quartzite. Brachiopod limestone.
Trias ? Permian ?	Dothak series and limestones on Sikkim-Tibet frontier.

Chitrāl, the Karakorum and the Pāmirs.

Between Afghānistān and Tibet lie Chitrāl and the Karakorum mountains, with the Pāmirs further to the north. Our very imperfect knowledge of these remote and mountainous tracts is derived principally from the journeys of Sir Henry Hayden [*Records, Geological Survey of India,* Vol. XLV, pt. 4, 271-325 (1916)], Mr. G. H. Tipper [*ibid,* Vols. LIV, 56-57 (1922), LV, 37-39 (1923), LVI, 44-48 (1924)], the Italian Expeditions [*Geographical Journal,* Vol. LXXV, No. 5 (May, 1930), 402-411] and those of the Vissers, Dr. E. Trinkler and Dr. H. De Terra [*Geologische Rundschau,* XIX, 41-51 ; XX, 120-136. *Zeitschrift für Geomorphologie,* V, 79-127 (1930)], and the collections of Sir Sven Hedin described by Dr. Bror Asklund [*Southern Tibet,* Vol. IX, pt. III, Chaps. 1-5.]

Trans-Himālayan geology.—The general distribution of formations between India and Turkistān consists, firstly, of a belt of igneous and metamorphic rocks extending from the vicinity of Kābul and Jalālābād, through Dīr and Swāt past Nanga Parbat to the north of the valley of Kashmīr into the Karakorum. To the north of this, sediments as old as Devonian and as young as Cretaceous extend through Chitrāl and Hunza, and are probably the continuation of the Palæozoic group round Bamian in Afghānistān. The region north of the Muztāgh range is sedimentary, and as the presence of Palæozoic and Mesozoic rocks in the Changchenmo region of Eastern Ladākh has long been known, and as Jurassic marine fossils were discovered by Major Kenneth Mason [*Records, Survey of India,* Vol. XXI, 86-99 (1928)], in the Aghil range, these rocks probably extend along the north of the Karakorum, parallel to the gneissic mass of Baltistān.

Karakorum.—In the last Italian expedition to the Karakorum, it was found that the Crystal Group, Broad Peak, and the Gasherbrum Group are composed of limestones with Permo-Carboniferous fossils, and the Golden Throne region is multi-coloured limestones [Ardito Desio, *Geographical Journal,* Vol. LXXV, No. 5, 402-411 (May, 1930)].

The Punmah basin is excavated in gneisses and granites and the peaks of the Skamri range are composed of crystalline limestone, but Fenestella shales are also found in the valley. The Sarpo Laggo and Shaksgam valleys are mostly in Permo-Carboniferous limestones.

Pāmirs.—To the north of this is a great belt of slates, extending from the Wakhan (Nicholas) range into the Taghdumbash Pāmir of Chinese Turkistān. Still further to the north is a calcareous group, the most prominent feature of the Russian Pāmirs (the Pāmir limestone), succeeded northwards by a belt of carbonaceous slates, probably in part the Wakhan slates, but associated with Upper Devonian shales and limestones. Beyond this again is a typical development of the Ferghana series.

It is greatly regretted that Dr. Hellmut De Terra's greatwork "Geologische Forschungen im westlichen K'un-Lun und Karakorum-Himalaya" (Berlin, 1932) arrived too late for the incorporation of his important results.

Chitrāl.—In Chitrāl the age of the oldest rocks present is very uncertain. The Chitrāl slates have yielded upper Palæozoic fossils, but they may in part represent older formations as well. Granite intrusion and its associated metamorphism and destruction of fossils have confused the evidence. Thus the Tirich Mīr *massif* is like a breccia on a large scale, of intrusive granite and garnet-, sillimanite-, and chiastolite-schists and crystalline limestone, but fragments of belemnites, found by Mr. G. H. Tipper in a less altered portion, show them to be probably in part Jurassic, though the presence of crushed conglomerates in places indicates that they may be of different ages. The Mirkanni granite is intrusive into a series of unfossiliferous black slates and altered limestones, and itself passes laterally through diorite into dolerite.

Unfossiliferous Lower Devonian rocks usually occur faulted against the Reshun conglomerate and shales, of Upper Cretaceous or Lower Tertiary age. A good fauna of the Upper Devonian has been recorded from the rocks above them, and a section at Parpish gives an apparently conformable sequence from the Lower Devonian to the Fusulina limestones (Carboniferous). At the Baroghil Pass, a band of ferruginous Upper Devonian rocks is faulted into the Fusulina limestones. The Sarikol shales, assigned to the Lower Carboniferous by Sir Henry Hayden, were found by Mr. G. H. Tipper to contain *Orthoceras* and crinoids, and are probably Upper Devonian. They may be the continuation of the ferruginous Upper Devonian of the Baroghil Pass.

On the north side of the Tirich valley, patches of Fusulina limestone occur in highly folded crystalline limestones, while shales further to the south-west have yielded *Syringothyris* and *Fenestella*. The intrusion of the Tirich Mīr granite was later than the Fusulina limestones.

The next succeeding formations are Middle Cretaceous limestones with *Orbitolina* and *Hippurites*, the latter being associated with the Reshun conglomerate and shales and appearing along the fault between them and the Lower Devonian.

In Chitrāl we find represented both the life-provinces of the Himālaya and of western Europe. On the west we have a well-developed Upper Devonian fauna, a great thickness of Fusulina limestone and a shallow-water facies of the Trias-Jurassic, contrasting with the absence of Devonian fossils and of Fusulina limestone in the east, with a well-developed marine facies of the Trias. In the Pāmirs the Upper Devonian fauna is distinct from that of Chitrāl and resembles that of the Urals, with certain American elements. The Fusulina limestones of Upper Carboniferous age were deposited in the Eurasiatic sea which stretched across Chitrāl into Turkistān, and in this sea the great volcanic series of Kashmīr and Turkistān began to be formed before the close of the Carboniferous, lasting into the Permian. The Zewan beds of Kashmīr, at the top of these volcanics, are of later date than the Fusulina limestones of Chitrāl.

Eastern Pāmirs.—In the Middle Devonian the "Kunlun transgression" of the sea deposited shales and limestone on a continent of ancient gneisses and

schists. A second transgression in the Carboniferous laid down, in the western Kunlun, limestones with *Productus* and foraminifera, concordantly overlying the rocks of the Kunlun transgression. Above these are the Cretaceous deposits of Yangi Hissar and red sandstones and conglomerates, with gypsum and salt, belonging to the Tertiary.

The Eastern Pāmirs have three well-marked geological divisions. The oldest may comprise the whole of the Palæozoic, folded into a complex, and intruded by granite. The folding may be of Hercynian age, and the granite intrusion late or post-Carboniferous. Younger than these are the lacustrine Angara slates, which have a very limited Trias-Jurassic range, and are moderately metamorphosed. On these the Cretaceous-Tertiary group is clearly discordant, and the lowest Cretaceous beds resemble flysch. In the Pāmirs the strike is E.-W., curving round to NE.-SW. and NW.-SE. at the western and eastern ends respectively, in concordance with the great re-entrant bend of the main Himālaya (p. 317) and this is also reflected in the Hindu Kush and the Karakorum.

CHAPTER 34.

PAST HISTORY OF THE HIMĀLAYAN AREA.

The Purāna sea.—We may now attempt to sketch roughly the past geological history of the Himālayan area. Our knowledge of the nature and distribution of the Archæan rocks is as yet too scanty to permit of any attempt to reconstruct the conditions prevailing at any part of that period and our history opens at the time when a shallow sea lay over Central and Northern India and extended into the Himālayan region, covering most of the area now lying on the Indian side of the axis of the present Great Himālayan range. In this were deposited beds of conglomerate, shale, sandstone and limestone, the materials for which were derived from the degradation of the Archæan rocks, exposed in parts of what is now Peninsular India and also along the Tibetan edge of the Himālayan zone between Assam and Kashmīr. The beds thus laid down are known as the Purāna group in the Peninsular area [T. H. Holland: *Trans. Mining and Geol. Inst. of India.* Vol. I, 48 (1906)] and include the Baxa, Jaunsār, Attock and Simla slate formations of the Himālaya. The connection of the one area with the other has still to be proved and the reference of the old unfossiliferous Himālayan sediments to the Purāna group is consequently as yet only conjectural, but the conjecture has an air of probability which renders it for the moment the most suitable working hypothesis. Hence it is now generally believed that the Purāna sea not only covered much of the Peninsula but also extended over what are known as the lesser ranges of the Himālaya. Whether it extended northwards beyond the Himālaya we are unable to say since much of the interior of Tibet is covered by much younger deposits, but there is evidence to show that land existed in the Himālaya at least during part of the Purāna era, and the sea may therefore have been bounded on the north by a Tibetan continental area.

The Dravidian era.—The next era of which we have a record in the Himālaya is that named by Sir Thomas Holland the *Dravidian*; it begins with the conglomerates and other shallow-water deposits of the Haimanta system and extends to the period of disturbance of upper Palæozoic age characterised by the Tālchir boulder-bed of Peninsular India, the Blaini boulder-bed of Simla and the great outburst of volcanic activity in Kashmīr. It extends from the Cambrian, or perhaps earlier, almost to the end of the Carboniferous.

Haimanta period.—The Haimanta, the oldest of the Dravidian systems, is characterised by deposits of detrital origin such as conglomerates, sandstones (quartzites) and slates, with only rare and insignificant beds of limestone at its upper limit. It is evident therefore that it was laid down in shallow water near a coast line and the absence of any post-Purāna beds among the rocks

of the Himālayan zone suggests that the present southern boundary of the Haimanta deposits marks approximately an original limit of deposition and consequently the southern shore of the sea in which the Haimantas were laid down. The relations of the Haimantas to the Purāna rocks of the Himālayan zone have not yet been worked out and it is not known definitely whether there is a gradual and conformable passage from the one into the other or whether the lower beds of the Haimantas are contemporaneous with the upper strata of the Purānas, nor is it possible to say at what period the Himālayan zone of Purāna rocks first became a land-surface. The presence of rocks of the Haimanta system in Kumaun, Garhwāl, Spiti and Kashmīr proves that these areas at least were submerged, whilst during the latter part of the Haimanta period the sea extended also to the Salt Range of the Punjab where the Cambrian rocks contain a species of trilobite identical with one from the uppermost Haimantas of Spiti [F. Cowper Reed, quoted in *Records, Geological Survey of India*, Vol. XXXVI (1908)]. Westwards the same sea probably extended at least as far as the Hindu Kush and Afghānistān, but it was not connected with the Cambrian sea of Europe, for the fauna of the fossiliferous rocks of this age in the Himālaya has nothing in common with that of the European Cambrian. On the other hand, there are decided affinities between the Cambrian fossils of the Himālaya on the one hand and those of China and North America on the other, and this has been regarded as evidence of a sea connection between the Himālaya and America during late Haimanta (Middle Cambrian) times.

The latter part of the Haimanta period was marked by local disturbances in Spiti and probably also in Kashmīr, and the presence of a conglomerate lying unconformably on the Middle Cambrian beds proves that the coast-line had moved temporarily northwards and the beds already deposited had emerged from the sea and undergone denudation. Normal conditions appear to have been soon restored throughout the Himālaya, but the absence from the Salt Range of any representatives of the post-Cambrian and pre-Tālchir system indicates that this range was now cut off from the Himālayan marine area and became a land-surface.

Muth period.—The next geological epoch, the Muth, which approximately coincides with the Silurian (Ordovician and Gothlandian) of Europe, extending into the Devonian, is remarkable for the great westerly extension of the Central Asian sea. The southern coast-line appears to have remained for a long period, at least until Lower Carboniferous times, much as it was after the Salt Range was cut off from the sea which covered the Himālayan area at the close of the Cambrian epoch, but the Tethys now encroached westwards and became linked up with the Palæozoic sea of Europe. Evidence of this is to be found in the character of the fossils of the representatives of the Upper Silurian, Devonian and Carboniferous systems in the Indian area, which bear a marked resemblance to those of the same systems in Europe, certain species being common to both

areas. During the Devonian period the sea covered all the northern portion of the Himālayan area and extended eastwards into Burma, south-eastern Tibet and China. Westwards it appears to have extended through Kashmīr, over what is now the Hindu Kush, into Afghānistān and northwards to the Pāmir and the Tien Shan; its record is not very clear in the greater part of the Tibetan zone of the Himālaya, where fossils of Devonian age are scarce, having been found only at rare intervals, but there is no evidence of any break in the continuity of marine deposits between the beginning of the Muth (Silurian) period and the middle of the Carboniferous. The latter period, however, saw many changes along the southern coast of the Tethys and ushers in the next and latest era in the geological history of India, that named by Sir Thomas Holland the *Aryan.*

India now became definitely established as an integral part of that great continent of Gondwānaland, which extended to South Africa on the one side and Australia on the other and on which flourished the flora of *Glossopteris* and *Gangamopteris* familiar to us from the rocks of the Indian coalfields. Below the beds in which these fossils occur, there is found in Australia, Africa and India a peculiar boulder-bed or tillite, which bears unmistakable evidence of having been deposited at a time when glacial conditions prevailed; the boulders found in it are facetted, polished and scratched whilst the rocks on which it lies are grooved and polished in a manner characteristic of the action of a glacier. This tillite, known as the Tālchir boulder-bed, has been proved to exist in the Himālaya as the Blaini boulder-bed and is an important member of the stratigraphical series of the Salt Range, where its glacial origin has been proved beyond a doubt. On the Indian Peninsula it is usually regarded as of fresh-water origin, but in the Salt Range it is associated with marine beds, and would therefore appear to have been deposited in the sea. The materials of which the boulders are composed for the most part belong to a group of rocks now exposed in Rājputāna and it is therefore clear that, during the early Gondwāna glacial period, Rājputāna was a land-surface whence glaciers flowed northwards to deposit their imbedded boulders in the Salt Range sea, which was presumably a southern arm of the Tethys.

Panjāl volcanic phase in Kashmīr.—Whilst these changes were taking place in the Salt Range, Kashmīr, which had formerly been covered by a shallow sea in which the shales and conglomerates of the Agglomeratic Slate series were deposited, had become the scene of great volcanic activity; masses of lava were poured out and, solidifying, formed what we now know as the Panjāl traps. These have been regarded as of submarine origin, but the evidence of this is not convincing; ashes certainly fell into the sea, where they were interstratified with marine limestones, as at Imbersilwara to the west of the Wular lake. Elsewhere the lavas may have been poured out over a land-surface, and it is possible that at this period Southern Kashmīr was an archipelago of volcanic islands.

At the close of the volcanic phase the peculiar *Gangamopteris* flora of Gondwānaland had spread to Southern Kashmīr, which must therefore have become connected with the mainland. But the sea soon encroached again and the plant-bearing Gangamopteris beds were covered by the Zewan beds, typical marine deposits with fossils of Permian age. These again pass upwards into the Permian Productus shales which are overlain by the fossiliferous limestones of the Lilang system (Trias); from the Gangamopteris beds upwards to the Lilang system there is no sign of any important break in continuity of the deposits, and it would therefore appear that the close of the Panjāl volcanic period marks the beginning of an era of subsidence and uninterrupted deposition, which lasted from the middle of the Carboniferous epoch until early Jurassic times, and throughout the whole of which Kashmīr lay beneath the waters of the Tethys.

Subsequent tectonic disturbances in Spiti and Kumaun.—In other parts of the Himālaya there is no evidence of violent disturbance having taken place during the volcanic period of Kashmīr; in Spiti there was slow, but steady rise of the sea-floor, resulting in a gradual northerly displacement of the coast-line, and what had formerly been an area of comparatively deep water was converted into a shallow coastal platform or possibly an estuary, in the sands and muds of which the remains of plants carried down from the land became embedded. But the remainder of the Carboniferous epoch was a period of some instability, and is marked by oscillations of the sea-level. These, however, were for some time comparatively trifling, but, at the close of the Carboniferous period, a steady rise of the land and northward retreat of the sea set in; almost the whole of the Himālaya to the east of Kashmīr appears to have become a land surface and remained such for a considerable length of time, long enough, in fact for the removal by denudation of beds some thousands of feet in thickness. In parts of Spiti, in Kumaun, and in Garhwāl, the whole of the deposits laid down during the Carboniferous and Devonian epochs, and even a great part of the Muth system, were removed before the land was resubmerged and the waters of the Tethys once more covered this part of the Himālaya.

It is interesting to note that these two periods of disturbance were not contemporaneous: that of Kashmīr occurred at the end of the Dravidian era, while the Central Himālayan disturbance was of more recent date and is not reflected in any corresponding movement in Kashmīr, having been probably of only local importance.

The world-wide extension of the earlier (Panjāl) disturbance.—The earlier disturbance, however, belongs to a different category. It corresponded in time with the far-reaching changes which ushered in the Gondwāna glacial epoch in India, Australia and South Africa. Recent work in Kashmīr has led to the conclusion that these changes occurred towards the end of the Carboniferous period a time when marked changes in the distribution of land and sea began to take

place in many parts of the world. Throughout Asia it is characterised by a great extension of the sea and the consequent overlap of marine deposits of Permo-Carboniferous age upon older beds. Evidence of the former presence of this sea can be found in the Salt Range [*Manual of the Geology of India,* 2nd edition, 123 (1893)], in S. E. Afghānistān and the neighbourhood of the Khyber [H. H. Hayden: *Memoirs, Geological Survey of India,* Vol. XXVIII, 108 (1900)], in Baluchistān [*General Report, Geological Survey of India,* for 1901-02, 31 (1902)], in Northern and Western Afghānistān [C. L. Griesbach: *Records, Geological Survey of India,* Vol. XX, 96 (1887)], Persia [J. de Morgan: *Mission Scientifique en Perse,* III, 1905)], Kashmīr [R. Lydekker: *Memoirs, Geological Survey of India,* Vol. XXII (1883)], the Central [H. H. Hayden: *Memoirs, Geological Survey of India,* Vol. XXXVI, pt. 1 (1904)] and Eastern Himālaya [C. Diener: *Records, Geological Survey of India,* Vol. XXXII, 189 (1905)]; eastward it extended into China and westward into Europe [Th. Tschernyschew: *Mem. Com. Geol., St. Petersburg,* XVI, No. 2 (1902), and *Records, Geological Survey of India,* Vol. XXXI, 111 (1904)].

Of the northerly extension of the sea beyond the Indo-Tibetan frontier we as yet know little, but among the exotic blocks of Kumaun, already referred to (*supra.* pp. 307, 309), are masses of limestone containing a fauna similar to that of the Productus limestone of the Salt Range, and we therefore conclude that Ngari Khorsum at least was submerged at this period.

Extension of the Dravidian Tethys over Tibet.—In this connection we may draw attention to the important and interesting work carried out in China by Messrs. Bailey Willis, E. Blackwelder, and R. H. Sargent, the results of which have been published by the Carnegie Institution of Washington [*Research in China* (1907)]. In the second volume Mr. Willis discusses the distribution of land and sea in Eastern and Central Asia during past geological ages, and assumes that, throughout the whole of the Palæozoic era, Tibet was a continental area, which he designates *Isle Tibet.* Having regard to our present ignorance of the geology of the greater part of Tibet, we can offer no direct observations bearing on this question; but if we turn to north-eastern Ladākh, we find Palæozoic rocks exposed in the neighbourhood of Changchenmo and Pangong Lake, and if, as appears to be the case, the trend of these beds is the same as that of the rest of the Tibetan zone in Kashmīr, Spiti and Kumaun, we should expect to find them well to the north of the head-waters of the Indus and the Brahmaputra in Western and Central Tibet. We are, therefore, inclined to believe that Palæozoic beds do occur in the great lake-basin of Central Tibet. They may possibly be hidden by the younger (Mesozoic) deposits to which we shall refer subsequently, but it may reasonably be expected that they will be found to crop out here and there, and thus prove that the sea in which the Dravidian (Palæozoic) rocks of the Tibetan zone were laid down was not, as has been assumed, merely a strait

connecting Eastern and Western Asia, but extended northwards over a great part of Tibet.

Extension of the Aryan Tethys.—Towards the close of the Palæozoic era, the Central Asian sea, which had extended from India to China on the one side and Europe on the other, gradually began to recede westwards, and in Triassic times much of China had become a land-surface. The sea, however, still lay over the Himālaya, and its connection with the European sea is proved by the large number of identical species of marine fossils found in the Triassic deposits of the Alps and the Himālaya. During the earlier part of the Triassic epoch the Salt Range formed part of the Tethys, which also covered Kashmīr and Hazāra, and appears to have extended into Eastern Afghānistān. Later on, connection with the whole of China, except the southern part, appears to have been cut off, and in Upper Triassic times the Salt Range also became a land-surface, but the sea extended from Eastern Afghānistān into Baluchistān, and also from Kashmīr through the Pāmir into Bokhāra. These changes did not affect the Himālayan area and Kashmīr, both of which remained submerged throughout nearly the whole of the Mesozoic era.

Its vicissitudes during the Jurassic period.—During the Jurassic period great changes in the distribution of land and sea took place in Asia. The continental phase, indications of which are first to be found at the close of the Palæozoic era, became largely developed, and there arose on the north a great continent named by Suess " Angaraland " [*La Face de la Terre*, III, 27 (1902)], which was analogous to Gondwānaland on the south, and the site of which is now marked by a series of fresh-water beds and coal-seams, comparable to the Gondwānas of India. Communication between the Himālayan Tethys and the Mesozoic sea of Europe remained open, and the whole of Southern Tibet was submerged. At the same time the sea extended once more to the Salt Range and thence through Baluchistān and Southern Afghānistān to Persia. Northern Afghānistān, however, became dry land, on which flourished a flora similar to that of Angaraland at the same period. That the latter part of the Jurassic epoch was characterised by the gradual shallowing of the Himālayan and Tibetan sea is proved by the nature of the uppermost Jurassic deposits, the Spiti shales, which are composed of fine detrital sediments alternating here and there with beds of coarser material.

Great extension (transgression) of the sea during the Cretaceous period.—Similar conditions prevailed for the most part during early Cretaceous times, but in the latter part of the period a great extension of the sea took place and many areas that had previously been land became submerged. Connection, through Northern Africa and North-Western India (Baluchistān and Afghānistān), between the Mediterranean of Europe and the sea of Western India was now thoroughly established, and its progress is seen in the overlap of the Upper Cretaceous beds over older formations which had been subjected to sub-aërial erosion during Ju-

rassic and early Cretaceous times. The Cretaceous sea extended along the whole of the site of what we now term the Tibetan zone of sedimentary rocks and probably stretched far to the north over much of Tibet. Eastern Tibet and China, however, were now a continental area.

This "transgression" of the Upper Cretaceous sea indicates a widely extended subsidence of the land, affecting North-Western India, Afghānistān, Western Asia and probably much of Tibet. On the Indo-Tibetan frontier, however, there was no marked movement of subsidence, for the Cretaceous deposits of the Tibetan zone of the Himālaya are largely characterised by sediments such as are laid down in the neighbourhood of a coast-line. Associated with these on the southern frontier of Ngari Khorsum are beds of tuff, which indicate the presence of volcanoes at no great distance and prepare us for the volcanic disturbances that ushered in the great epoch of mountain-building which produced the mighty ranges of the Himālayan chain.

We have already seen that the Cretaceous sea lay over a great part of Tibet and extended as far south as the northern frontier of Sikkim. At the same time the Shillong Plateau was under water and was part of the floor of an ocean which extended along what is now the east coast of the Indian Peninsula but was then the submerged edge of Gondwānaland, which, at the beginning of the Cretaceous period, still survived as a continent, though probably much reduced in size; this continent, however, appears to have begun to break up during the latter part of the period and in Upper Cretaceous (Senonian) times direct connection was established between the North African sea and the Pacific, through a strait separating India from Madagascar.

Possible connection between the Tethys and the Indian Ocean.—It is possible that there may have also been a narrow and shallow arm of the sea running through that curious depression which is now filled by the Indo-Gangetic alluvium. That in early Tertiary times the western sea flowed over what is now the south-western foot of the Himālaya almost up to the meridian of Naini Tāl is clear from the presence of nummulitic limestone all along that belt, and in the Tal beds there is some indication of a shallow arm having reached Garhwāl at a much earlier period, probably sometime during the Jurassic epoch [C. S. Middlemiss: *Records, Geological Survey of India,* Vol. XX, 26 (1887)]; it would not, therefore, be surprising to find that the great Upper Cretaceous transgression also affected this area. The absence of any Cretaceous rocks in this part of the Himālaya is certainly an argument against this supposition, but they may either have been completely removed by denudation at a subsequent period or may be merely hidden by the alluvium.

There is at present no evidence that the arm of the Pacific in which the Cretaceous beds of Burma and Assam were deposited was connected with the Tibetan sea; this can only be decided by exploration in the unsurveyed country around the head-waters of the Luhit Brahmaputra and the Irrawaddy. If there

was no connection between the two oceans, the Eastern Himālaya must have been at this time either a narrow peninsula running out from the Chinese mainland or else an isthmus connecting that continental area with Gondwānaland.

Periods of volcanic activity.—Several periods of volcanic activity have left their records in the Himālayan area. Of these, two occurred during Purāna times and a third after the middle of the Carboniferous period; another has been ascribed [A. von Krafft: *Memoirs, Geological Survey of India,* Vol. XXXII, pt. 3 (1902)] to the Upper Cretaceous epoch, a period marked in the Peninsula by the great outpouring of lava which constitutes the Deccan trap. From this time onward there was a steady retreat of the sea from Tibet and the adjacent portions of the Himālaya; there were, no doubt, local oscillations of the coast-line as indicated, for instance, by the overlap of the nummulitic beds of Kashmīr over older fresh-water deposits, but by the end of the Eocene period, Tibet and the Himālaya had finally become dry land, and the western sea had been driven back to Sind and Baluchistān. This last phase in the marine history of the Himālayan area was accompanied throughout the whole Indo-Tibetan region [A. von Krafft: *Memoirs, Geological Survey of India,* Vol. XXXII, pt. 3 (1902); H. H. Hayden: *Memoirs, Geological Survey of India,* XXXVI, pts. 1 and 2] by great volcanic activity, which was no doubt intimately connected with the crustal disturbances to which the origin of the Himālaya is to be attributed. The igneous phase began with the intrusion of masses of granite into the sedimentary deposits of the Tibetan zone; subsequently there were outbursts of basic lavas which flowed over parts of Ladākh, Ngari Khorsum and western Tibet, whilst dykes of basalt and allied rocks were formed by the injection of the basic magma into fissures both in the sedimentary beds and in the granite.

Volcanic activity seems to have been most intense in the neighbourhood of Lake Mānasarowar, which has more than once been an area of special disturbance, and the comparatively recent change in the direction of flow of the upper Brahmaputra, to which attention has been drawn in a previous chapter (*supra,* p. 221), is an indication of elevation having occurred in this area at no very distant date in the past.

Although the volcano of Barren Island in the Bay of Bengal was active during the past century [F. R. Mallet: *Memoirs, Geological Survey of India,* Vol. XXI, pt. 4 (1885)], and other volcanoes in Eastern Persia on the immediate confines of Afghānistān are not yet extinct [E. Vredenburg: *Memoirs, Geological Survey of India,* Vol. XXXI, pt. 2 (1901)], there is no indication of recent volcanic activity in the Himālayan region. In Central Tibet Mr. Littledale records a large number of volcanoes, none of which, however, appears to have been active at the time of his visit [St. G. R. Littledale: *Geographical Journal,* Vol. VII, 453 (1896). For numerous references to recent volcanoes in the Kunlun range see Suess: *La Face de la Terre,* III, 268 (1902)].

CHAPTER 35.

AGE OF THE HIMĀLAYA.

Post-Purāna crustal movement.—There is no evidence to show that the Himālaya, as a great mountain range, are older than the latter part of the Eocene period. There are undoubtedly signs of former periods of considerable folding; thus, the Purāna rocks were folded and compressed during the earth-movements that resulted in the birth of Gondwānaland, but the Himālayan area then became the northern coast of the new continent and was not necessarily a mountain range.

Upper Cambrian movement.—Towards the end of the Haimanta (Cambrian) period local folding again took place, for we find the (Ordovician) conglomerates of the Muth system in Spiti lying on the eroded edges of folded beds of Middle Cambrian age. After this, no tectonic movements of great intensity seem to have occurred until the last upheaval of the Himālaya and Tibet in Tertiary times. Movements there undoubtedly were, as, for instance, during the Carboniferous period when marine sediments were raised up, denuded and again depressed beneath the sea, but the parallelism to these older beds of the younger deposits subsequently laid down on them shows that the former underwent no contortion, but were merely subjected to a gentle uplift without violent crustal compression. Thus we have no evidence of mountain building in the Himālayan region before the Tertiary period.

Eocene and Oligocene disturbances.—The movement which was so pronounced during this latter period probably began in late Cretaceous times and continued throughout the Eocene and Middle Tertiary periods. That it was still active during the Pliocene epoch is proved by the great series of overthrusts along the outer foot of the Himālaya, the origin and history of which have been so admirably traced out by Mr. C. S. Middlemiss [*Memoirs, Geological Survey of India*, Vol. XXIV, pt. 2 (1890)].

Pliocene and post-Pliocene disturbances.—The movements which affected the Siwālik (Pliocene) deposits of the outer Himālaya were not confined to the neighbourhood of the Indo-Gangetic plain, but extended to such widely separated regions of Afghānistān and Ngari Khorsum. In the former area all the great river valleys of Eastern Afghānistān are filled with beds of sand-rock and conglomerate which are exactly similar to the Siwālik deposits of the Indian "dūns" [*Dun* is the Indian term for the narrow longitudinal valleys lying between the outer Siwālik ranges and the higher hills of the Lesser Himālayan ranges (p. 96)], and have, like them, undergone much folding and tilting. In Ngari Khorsum (Hundes) similar deposits were observed by Mr. Griesbach in the Nukchung valley [*Memoirs, Geological Survey of India*, Vol. XXIII (1891)], and these also

show signs of considerable disturbance. As the age of these deposits is Pliocene, it is clear that even at the end of this epoch the crustal movement, to which the Himālaya owe their origin as a mountain range, was still active.

Ossiferous beds of Ngari Khorsum.—In the next geological period, however, the Himālaya appear to have reached a stage of comparative quiescence. In the upper valley of the Sutlej in Ngari Khorsum there are vast deposits of boulders, sand and clay, in which occur remains of mammals [R. Strachey: *Quarterly Journal, Geological Society,* Vol. VII, 292 (1851); C. L. Griesbach: *Memoirs, Geological Survey of India,* Vol. XXIII (1891)] regarded by Mr. Lydekker as of Pleistocene age [*Records, Geological Survey of India,* Vol. XIV, 178 (1881)]. The exact origin of these deposits has not been definitely ascertained, but they are now generally regarded as fluviatile, though possibly also in part lacustrine [*Manual of the Geology of India,* 2nd edition, 422 (1893)]. They lie unconformably on the tilted Pliocene sandstones, but are themselves almost perfectly horizontal, thus showing that, since their deposition, no violent disturbance has affected this part of the Himālayan region.

Karewas of Kashmīr.—In the valley of Kashmīr, very similar deposits occur, where they are known under the name of *Karewa.* These have been described from time to time by various observers as of lacustrine origin, but from a detailed study of them, Mr. R. D. Oldham concluded that their mode of origin was similar to that of the alluvial deposits in process of formation in the same valley at the present day [*Records, Geological Survey of India,* Vol. XXI, 157 (1888); T. H. Holland: *Records, Geological Survey of India,* Vol. XXXII, 152 (1905)].

Mr. C. S. Middlemiss has observed [*Records, Geological Survey of India,* Vol. LV, 241 (1923)] that the Karewa formation reaches elevations of over 11,000 feet on the Pīr Panjāl range, and must have swept right over it. It has no relation to any valley system or lake basin of the present day, and lies beneath the post-Pliocene glacial deposits, in folds with dips sometimes amounting to 40 or 50 degrees, and with a thickness of 4,500 feet or more. He suggests that it should perhaps be regarded as Upper Siwālik in age.

If we are right in regarding the ossiferous deposits of Ngari Khorsum and the Karewas of Kashmīr as of Pleistocene age, we are led to infer that the general features of the Himalaya were at that period much as they are at the present day. We have already seen (*supra,* p. 280) that the main drainage lines date back as far as the Pliocene epoch, and that the rivers which brought down the sand and boulders from the mountains to build up the Siwāliks of the dūns and of Hundes were the direct ancestors of our modern Sutlej and Ganges.

Pre-Pliocene drainage system.—Of the topography of the Himālayan area before this period we as yet know practically nothing, but it is clear that the old coast-line of Gondwānaland cannot have been very far from the present southern boundary of the Tibetan zone of sediments, and detailed surveys will very possibly

reveal the sites of pre-Pliocene rivers, as indicated by the coastal or estuarine deposits laid down at their mouths. During the Palæozoic and much of the Mesozoic periods, when the Indian Peninsula and the zone of oldest rocks of the Himālaya formed part of Gondwānaland, rivers must have flowed northwards from India to the Tethys, and we have already noticed the evidence of the direction of drainage afforded by the pebbles of the Salt Range boulder-bed (*supra*, p. 336). In the distant future, when the geology of the Himālaya is known as intimately as that of England and parts of continental Europe at the present day, the presence of deposits like the Gangamopteris beds of Kashmīr may enable us to locate, among the sedimentary beds of the Tibetan zone, the sites of some of the estuaries of this old drainage system, but all traces of its river-valleys through the central zone must have long since been removed by the subsequent processes of denudation, whilst the new drainage system, which has gradually arisen in a reverse direction has replaced and obliterated the old. [R. D. Oldham, *The Valleys of the Himālayas, Geographical Journal*, XXX, 512 (1907)].

Indus valley an old structural depression.—Of the present river-valleys of the Himālaya, one at least can be shown to have existed as early as in the Eocene period. In the Upper Indus valley in Kashmīr are beds of either fresh-water or estuarine origin, which are of Eocene age. They form a long and narrow strip in the present valley and mark the position of an old river-valley or of an estuary, which was apparently connected with the Tibetan portion of the Tethys.

Subsequent oscillations of the relative level of land and sea led to these fresh-water beds being covered by marine deposits containing nummulites, but the latest phase in the elevation of this area has resulted in the removal by denudation of the cap of younger beds and the old valley has been thus once more exposed to view. The presence of a valley along approximately the same line at two periods separated by such a great interval of time shows that its origin is not due to mere erosion, but must be attributed to structural causes, connected with the folding of the earth's crust, and producing a depression which was first outlined at least as long ago as the Eocene period. This, again, is a further indication that the movements which finally resulted in the upheaval of the Himālaya were already operative at that period.

Recent movement.—Although the practically undisturbed condition of the Pleistocene beds of Ngari Khorsum leads us to suppose that there have been no violent disturbances in the Himālayan region since their deposition, many facts suggest that the apparent quiescence is only comparative and that movement tending to a further rise of the Himālaya is now in progress. That movement has not ceased is evident from the frequent earthquakes occurring in the Himālaya and Afghānistān, and such catastrophes as the Kashmīr earthquake of 1885 [E. J. Jones: *Records, Geological Survey of India*, Vol. XVIII, 221 (1885)], those of Shillong in 1897 [R. D. Oldham: *Memoirs, Geological Survey of India,*

Vol. XXIX (1899), XXX (1901)] and of Kāngra in 1905 [C. S. Middlemiss: *Records, Geological Survey of India,* Vol. XXXII, 258 (1905)] forcibly remind us that the Himālayan region is by no means at rest. [For a complete list of Indian earthquakes up to the end of the year 1869, see T. Oldham: *Memoirs, Geological Survey of India,* Vol. XIX, pt. 3 (1883)].

Evidence of uplift.—These, however, do not serve to give us any indication of the direction of movement, which we can at present deduce only indirectly from other phenomena. Amongst these may be mentioned the observations already referred to (p. 273) in connection with the apparent progressive desiccation of the Tibetan lakes, a phenomenon which has been regarded as due to the rise of the Himālaya and consequent cutting off from Tibet of the moisture-laden monsoon winds. Evidence of such rise being now in progress is also to be found in the present condition of the chief Himālayan rivers. The general tendency of a river rising in a mountainous region and flowing out on to a plain is to remove material from its upper reaches in the mountains, where its gradient is steep, and deposit it on the plains at their foot; as this process proceeds, the river gradually cuts down its channel, working most rapidly in the higher regions where its gradient is naturally steeper, and less rapidly lower down. Where the gradient is steep and the current rapid, the water carries with it large quantities of material such as boulders, pebbles and sand; where, however, the current is less rapid in the lower reaches, its force is insufficient to carry the whole of its load and some or all of it is deposited. The tendency of the river is therefore to remove material from its upper reaches and deposit it in the lower, thus producing a flattening of its gradient throughout, in consequence of which the depositing section of the stream gradually creeps further and further back towards its head. If, during this process, the land round the head-waters of the stream undergoes a movement of elevation, the gradient and consequently the erosive power of the stream will be increased and the water begin to cut a channel through the deposits which had accumulated in the lower valleys. This phenomenon is known as the rejuvenation of a stream.

At the present day the great Himālayan rivers are not depositing in their lower reaches, except near the points at which they debouch from the mountains, and consequently are not in that stage of equilibrium which characterises an old river. On the other hand, their valleys are cut through horizontal deposits of boulders and river-gravels, which can be seen to extend many hundreds of feet above the present stream-bed [H. B. Medlicott: *Records, Geological Survey of India,* Vol. IX, 55 (1876); R. Lydekker: *Memoirs, Geological Survey of India,* Vol. XXII (1883)]. It is clear, therefore, that where the rivers are now in the active stage of abrading, they were once depositing streams and filled their rocky valleys with the sands and gravels through which they have since re-excavated their channels. They have, therefore, undergone rejuvenation presumably due to uplift of the highlands amongst which they rise.

Date of this movement.—When this uplift began, we are not yet in a position to say, since we have at present no evidence of the age of most of these old river-deposits. It has already been pointed out that the ossiferous beds of Hundes are probably of Pleistocene age, whilst the Karewas of Kashmīr have been attributed to the same period, though they may be Upper Siwālik (Pliocene) (p. 343); the other high-level alluvial deposits found in the Sutlej and the Indus may be of the same age or may be of later date, but we are justified in assuming that during the Pleistocene epoch, and probably for some little time afterwards, little or no movement took place in the Himālaya, and the rivers gradually tended to assume a state of equilibrium, which, however, was subsequently disturbed by further elevation of the higher ranges and the Tibetan region, resulting in increase of gradient and consequent rejuvenation of the streams, and the present steep gradients of most of the Himālayan rivers lead us to conclude that uplift is either still in progress or has only quite recently ceased.

Cutting-back and capture.—Similar evidence of recent elevation of the higher ranges of the Himālaya has been deduced by Mr. R. D. Oldham from the manner in which many of the southward-flowing streams are rapidly cutting back into the catchment areas and capturing the drainage of the Tibetan rivers on the north [*Journal, Manchester Geographical Society,* Vol. IX, 112 (1893)]. Striking examples of this are furnished by the Ganges [*ibid.*], the Tīsta [H. H. Hayden: *Memoirs, Geological Survey of India,* Vol. XXXVI, pt. 2 (1907)], the Arun [A. M. Heron: *Records, Geological Survey of India,* Vol. LIV, 219 (1922)], and the Sind river in Kashmīr [R. D. Oldham: *Records, Geological Survey of India,* Vol. XXXI, 142 (1904)].

A most instructive example of this rapid cutting back of the southward-flowing streams on the southern flanks of Kānchenjunga in Sikkim has been described by Prof. Garwood [" The Geological Structure and Physical Features of Sikkim " in D. W. Freshfield's " Round Kangchenjunga ", 296 (1903)]. Here the Rathong Chu [Chu=stream or river (Tibetan)] and Praig Chu, feeders of the Great Rangit, have cut back their heads so rapidly that they have actually truncated and captured what was formerly an important eastward-flowing tributary of the Tīsta. So rapid has been the work of these two streams that they have cut deep chasms or gorges across the old valley, with the result that the remnant of this former tributary of the Tīsta is now only a small stream, which " occupies a nearly level upland glen, three miles in length and some 2,000 feet above the floor of the Rathong Chu, and this elevation is maintained nearly to its mouth, whence it empties itself by precipitous cascades into the valley beneath ". This rapid head erosion and " piracy " on the part of the Rathong Chu is ascribed to recent elevation of the Kānchenjunga *massif* lying to the north; such elevation would increase the gradient and consequently the erosive power of the Rathong Chu while not affecting that of the eastward-flowing stream, which would be merely tilted sideways [*op. cit.* 298; see also " Notes on a Map

of the Glaciers of Kānchenjunga" by the same author in *Geographical Journal*, Vol. XX, 13 (1902)]. Here we see that local uplift will account not only for the formation of a deep gorge on the flank of a range, but also to some extent for those curious side valleys which, as Prof. Garwood graphically expresses it, appear to be suspended in mid air high above the level of the main valley, which they join in a sheer precipice. The difference of level between these "hanging" valleys and the main stream is thus due partly to more rapid erosion of the channel of the latter, through a steepening of gradient attributable to uplift of the mountains at its head, but partly, in Prof. Garwood's opinion, to the recent occupation of the hanging valleys by glaciers which have protected them from the effects of river erosion.

Origin of gorges.—Such uplift has also been regarded as a contributory cause of the deep and narrow gorges to be seen in so many of the Himālayan rivers. In a previous part (p. 261), reference has already been made to these gorges and various possible modes of origin suggested. Two of these are of special interest, and are regarded as embodying the main principles involved. They are—

(1) that the Himālayan drainage system had been established before the ranges, across which the rivers now cut, had become axes of special elevation, and that when elevation finally took place its rate was not so great as to interrupt the course of the river, which was therefore able to keep its channel open by abrasion across the rising range;

(2) that the old rivers have been dammed by the rising ranges and their valleys thus become lakes, the waters of which eventually overflowed and carved out gorges.

The first of these theories, which we owe to Mr. H. B. Medlicott [*Manual of the Geology of India*, 1st edition, 676 (1879)], has been applied with striking success by Mr. R. D. Oldham to the river-valleys of the Himālaya and neighbouring areas. In the comparatively young mountains of Baluchistān, which was still under the sea after the Himālaya had become dry land, he has followed out the earlier stages in the process of the formation of gorges and has subsequently extended these principles to the Himālaya themselves [*Geographical Journal*. Vol. III, 169 (1894)]. He has suggested that the present gorges of the Indus and the Brahmaputra lie along the alignment of valleys which were defined at the time when the upheaval of the Himālaya first began and when a pair of longitudinal valleys was established along the northern face of the rising mass round the extremities of which the drainage escaped towards the south. This assumption is borne out by the observations of Mr. Medlicott, who has shown that the great Himālayan rivers are "antecedent" and that their debouchures in Siwālik times were where they are at the present day (*supra*, p. 280), whilst

the nature of the Indus valley Tertiary deposits is evidence of the existence of a structural valley along the line of the Indus at a very early date (*supra*, p. 344).

The second theory has been advanced by Sir Sydney Burrard to explain the origin of the gorge of the Brahmaputra [*Ann. Rep. Board of Scientific Advice for India*, 1905-06, 67; also *supra*, pt. III, 262]. He has suggested that an old river-valley, having become blocked by the rise of a mountain range, has been filled by a lake, the overflow from which has subsequently cut a channel resulting in the present gorge. Such a diversion of drainage has been shown by Mr. R. D. Oldham to have occurred in one instance in Baluchistān [*Records, Geological Survey of India*, Vol. XXV, 28 (1892)], but in this case there is no tendency for the new channel to become a gorge. The water, where it issued from a lake, would hold no sediment and would consequently have practically no abrasive power, hence, except in areas of extreme aridity, the sides of the outlet valley would be worn away by atmospheric denudation concurrently with the excavation of the new channel, and the valley would have gently sloping, rather than precipitous, sides.

There are several other difficulties in the way of the application of this process to the Himālayan gorges. In the first place, we should expect to find well-marked lake deposits in the basins above the gorges. These, however, have nowhere been recognised; the previously accepted views of the lacustrine origin of the Karewas of Kashmīr have been disputed [*supra*, p. 343; also Ellsworth Huntington: *The Pulse of Asia*, 22 (1907)], whilst the description given by the late Sir Richard Strachey of the Pleistocene deposits of the Upper Sutlej valley [*Quarterly Journal, Geological Society*, Vol. VII, 306 (1851)] points to an origin in part, if not entirely, fluviatile.

On the other hand, basins of this kind filled with fluviatile deposits, and in some cases even holding lakes, are commonly found above gorges in almost all parts of the world, but it can usually be shown that they are due to the obstruction caused by hard bands of rock running across the valley. Thus, in the case of the Sutlej, the stream after passing through the sedimentary beds of Hundes encounters the hard granite of the great Himālayan range; its rate of erosion is retarded, and, while slowly wearing its way down into a narrow trough in the hard rock, it works also laterally in the softer beds, and so produces a broad basin above, in which alluvial deposits accumulate, and a gorge or "narrows" below. [For details as to these processes see Sir A. Geikie: *The Scenery of Scotland* (1901); also Chamberlain and Salisbury: *Geology Processes and their results* (1905)]. Thus the gorges have been developed concurrently with the open basins behind the ranges rather than after, and as a consequence of the damming of, these.

The two hypotheses above quoted are mutually conflicting, but so little is yet known of the actual conditions of the Himālayan rivers that it is desirable to

keep both in view. One fact, however, is clear, namely, that until systematic observations have been made of most of the great Himālayan rivers on the lines of the admirable work of Mr. R. D. Oldham in the Sind valley in Kashmīr [*Records, Geological Survey of India*, XXXI, 142 (1904)] and of Prof. Garwood in Sikkim [*Quarterly Journal, Geological Society*, Vol. LVIII, 703 (1902): *Geographical Journal*, XX, 13 (1902); *Appendix* to D. W. Freshfield's *Round Kāngchenjunga* (1903)], we can make no advance in India in this most fascinating branch of historical research, the history of the surface features of the earth.

The Indobrahm.—In two papers published independently and almost simultaneously Sir Edwin Pascoe and Dr. G. E. Pilgrim have advanced an interesting hypothesis regarding the early river-systems of the Himālayan area [*Quarterly Journal, Geological Society*, Vol. LXXV, pt. 3, 138-155 (1919) and *Journal, Asiatic Society of Bengal*, New Series, Vol. XV, 81-99, (1919)]. Briefly stated, it is that in Eocene times, a gulf of the sea extended from Sind to Afghānistān, and east and south-east through the Punjab to near Naini Tāl. On the elevation of the Himālaya, this gave place to a river, the head-waters of which consisted of the Assam portion of the present-day Brahmaputra. This flowed west and north-west along the foot of the Himālaya as far as the north-western Punjab, where it turned southwards along the line of the modern Indus, into the Arabian Sea. This postulated river Sir Edwin Pascoe calls the "Indobrahm". Two rivers, which flowed into the Bay of Bengal, cut back and beheaded this old Indobrahm, the eastern of the two capturing the Assam portion to form the modern Brahmaputra, and the western gradually capturing the portion between Assam and the present Jumna. The Attock part of the present Indus was a tributary of the old river, which tributary cut its way back into Kashmīr, there capturing the head-waters of a large river which either drained north-westwards into the Oxus or curved south-west into Afghānistān,—the forerunner of the Tsangpo, but flowing in the reverse direction. One of the principal arguments put forward by Pascoe and Pilgrim in support of this hypothesis is the tendency of the tributaries of the supposed Indobrahm to flow in a direction opposite to that of the modern trunk river. If but one feeder had been observed to take a course contrary to that of the main stream, it might have been attributed to some local accident of topography, but when all the principal affluents of a long section of the river do so, it is indicated that the Indobrahm flowed from east to west, when the tributaries were developed, and that its direction of flow has been reversed. Another piece of evidence is the presence in the Ganges, Brahmaputra and Indus of identical species of fresh-water dolphins and turtles, which are not found elsewhere, and must have been evolved in a connected river-system. The former argument has been used by Sir Sidney Burrard (*supra*, p. 221) to show that the Tsangpo, the upper or Tibetan portion of the Brahmaputra, has also undergone reversal of its direction of drainage. In the passage referred to he concludes that the Tsangpo formerly flowed from east to west and conjec-

tures that it escaped from Tibet through the Himālaya either over the Phuto pass and through the defile of the Kāli Gandak, through the Karnāli basin or along the course of the present Sutlej or the Indus. Sir Edwin Pascoe (*loc. cit.*, p. 148) still further suggests that the early Tsangpo flowed west and north-west from Pemakoi to Gilgit, and that its uppermost waters were captured in turn, perhaps, first by the Irrawaddy or its tributary the Chindwin, and finally by the Indobrahm. The latter cut back westwards along the already excavated valley of the Tsangpo, capturing its tributaries one by one, and completely reversing its drainage. The Kāli Gandak and the Sutlej may have captured higher portions of this river, and the Attock tributary of the Indobrahm may have captured it in Gilgit.

CHAPTER 36.

ECONOMIC GEOLOGY OF THE HIMĀLAYA.

The Himālayan region is strikingly poor in minerals of economic value, there being only three industries which can be said to be established on a commercial basis; these are the salt and the slate quarries in Kāngra district and the sapphire and aquamarine mines of Kashmīr. Active prospecting by the Mineral Survey of Kashmīr, under Mr. C. S. Middlemiss, has resulted in the discovery of many mineral deposits of potential value.

Salt.—The salt quarries are situated at Guma and Drang in Mandi State; they are at present only of local importance, the output in 1932 being about 3,555 tons.

Slate.—The Kāngra slate quarries, which are at Kanyara, have been worked with considerable success for many years past.

The rock is not a true clay slate, but is sufficiently fissile for the production of slabs and roofing-slates.

Phyllitic slate, splitting into fairly thin glossy-surfaced laminæ and belonging to the Silurian system or older, is known near Banihal and a few other places in Kashmīr. It has already been extensively used with success for roofing many of the Banihal cart-road bungalows. A purer black slate from Mohri Dor in the Gulmarg hills is also known. Both these varieties, especially the latter, may have a large future of usefulness in Kashmīr.

Sapphire.—Some fifty years ago the beautiful azure blue sapphire of Sumjam in Padar, Zanskar, Kishtwar tahsīl, was accidently discovered at an altitude of 15,000 feet among rocks which have since been determined as felspathic pegmatite veins in actinolite-tremolite schist lenticles in the marble bands of the area. The actinolite-tremolite schist appears to have been a modification of the marble. Large quantities of excellent stones were found and they yielded considerable revenue to the Kashmīr Government and doubtless much profit to illicit traffickers in the stones as well as to those licensed to work the mines. Subsequently the actual source of the rock sapphires appeared to be exhausted, though the placer deposit continued to yield a diminishing output.

Later on, several new veins of corundum, sapphire and pink corundum (ruby) were discovered in the above area and in its neighbourhood. The quantity available of these as estimated by recent work of the Kashmīr Mineral Survey, is certainly very great. In colour, the sapphire is of a pale china-blue tint, but more generally it is a rich sky blue, which in the best stones becomes extremely vivid. Occasionally a more slaty blue tint appears.

An account of the sapphire and aquamarine mines, by A. M. Heron, is given in the *Himālayan Journal,* Vol. II, 21 (1930).

The colour is irregularly and unevenly distributed in the sapphire crystals, being found in stripes and patches of different dimensions among the milky grey and colourless corundum.

A reddish tint is also found, though somewhat rare. Where found it varies from pale pink to rosy red, and in a few cases to carmine with a slight blue tone in the red. The finding of true deep coloured rubies is probably only a matter of carefully working the veins and following them in depth.

Aquamarine.—The semi-precious gem-stone, aquamarine, a variety of beryl, is found at Dasu on the Braldu River, in Baltistān in the Skārdu tahsīl of Kashmīr.

The stones are of somewhat slight depth of colour, but have great limpidity and brilliance when cut and set suitably. In pendant size and form they have a most attractive appearance, and they are in considerable demand in Kashmīr by both Europeans and Indians. In cut gem form they are sold at Rs. 3-12 per carat, and in uncut form, at Rs. 21-12 per tola (about 58 carats).

Some veins of this gem-stone have also been discovered in Padar *ilāka,* but they have not been exploited so far. They bear aquamarine and beryl varying in colour from a pale or, perhaps one should say, delicate sea-green tint, and in one case to blue approaching sapphire-blue.

Mr. Tipper found [*Records, Geological Survey of India,* Vol. LV, 13 (1923)] beryls of pleasing colour and some of almost gem quality at Sirwigh-o-gaz, a summer grazing-ground in western Chitrāl.

Abrasives (polishing powder).—Near Khunamuh in the Vihi district, Kashmīr, occurs the geologically well-known Gangamopteris rock. When powdered to various degrees of fineness it makes a mild abrasive and effective polishing and scouring material for metals, marble, serpentine, cement floors, etc.

Antimony.—Sulphide of antimony (stibnite) occurs in some quantity near the Shigri glacier in the valley of the Chandra river in Lahaul. The locality has long been known [F. R. Mallet: *Memoirs, Geological Survey of India,* Vol. V, 165 (1886)], but no success has attended attempts to work it.

Arsenic.—A small production of orpiment has been reported from Chitrāl for years [*Records, Geological Survey of India,* Vol. LIV, 17 (1922)], from six deposits in crystalline limestones. Realgar occurs as well and fluorite is found in both minerals. At another locality, Partial [*Records, Geological Survey of India,* Vol. LV, 14 (1923)], only realgar occurs, in scattered patches in calcareous shales of Cretaceous age.

Specimens have also been obtained from the Rishipjerab valley in Hunza and the Shankalpa glacier in Kumaun [*Records, Geological Survey of India,* Vol. XXXV, 28 (1907)], but the amount available in either locality is unknown.

Barytes.—Barytes is found penetrating the Great Limestone of the Riasi tahsīl of Kashmīr in the familiar form of narrow veins at several places. Its

modern industrial uses for paint, lithopone, and in the ceramic and glass industries must await the general industrial development of the country and the provision of easy communications.

Bauxite, bauxitic clays and kaolin.—A very pure form of bauxite, forming a surface layer, averaging some 4 feet in thickness and passing downwards into bauxitic clay and kaolin or china clay, has been discovered at a large number of places in Jammu Province. Bauxite is an ore of aluminium, whereas the bauxitic clays are used for making refractories and the kaolin in the pottery industry.

The bauxite is of the diaspore variety, having one molecule of water only, and contains between 70 and 80 per cent alumina and 1 to 5 per cent silica. The coal of Jammu occurs in close connection with the bauxite, stratigraphically at an horizon 60 feet above it, and could be used for calcining the bauxite. The quantity of first grade bauxite has been estimated to be about 1,810,000 tons, that of the second grade being roughly about 10,000,000 tons, easily available at the surface. Kaolin, known locally as "makol", occurs in the neighbourhood of the bauxite and tiles and pottery articles have been made from it.

Bentonite.—Bentonite, a clay with several useful industrial properties, forms a continuous bed 2 feet thick in the gently dipping Siwālik conglomerates, extending for 28 miles, at least, in the neighbourhood of Bhimber, Jammu Province, Kashmīr.

Borax.—Borax is found in Ladākh, where it is obtained as an efflorescence from the surface of the alluvium of the Puga valley. The superficial coating is scraped up and boiled with water in coppers; the resulting brine is then cooled in small pits, when the borax crystallises out. The production at Puga is quite insignificant, almost the whole supply of borax brought into India being imported from Central and Western Tibet.

Chromium.—Pure olivine-chromite rock (dunite) has been discovered in the higher hills of Kashmīr near Drās, Bembat and Tashgam, where it is present in enormous quantities, forming large mountain masses. Without any road communications other than a bridle path, and with a high pass of 11,300 feet (the Zoji La) between it and the Valley of Kashmīr, it is practically impossible to consider this bulky ore for industrial purposes at present.

But in this connection it may be of some importance to remark that there is a possibility of finding platinum, which has not so far been discovered by the Kashmīr Mineral Survey, in the peridotites, pyroxenites and dunites of the above areas or further north-west in Gilgit Wazārat, if proper exploration is carried on. These are the rocks in which platinum is generally found.

Coal.—The chief occurrences of coal in the Himālaya are among the Gondwāna rocks of the Darjeeling Terai and Assam Duārs and in the Tertiary beds of Jammu and Kashmīr.

As already pointed out (*supra*, p. 287) the Gondwāna coal is usually too crushed to be of commercial value and such attempts as have hitherto been made to work it have not met with success.

Coal of excellent quality (semi-anthracite) occurs in the province of Jammu, Kashmīr, consisting of a number of seams 2 to 20 feet thick in the Subāthu series. Its continuity over a distance of 36 miles has been proved, though concealed here and there under debris or under the overlying rocks. The quantity may be reckoned to be over 100,000,000 tons easily available within a reasonable depth. Samples from the various deposits yield 60 to 82 per cent of fixed carbon.

In the Karewa (Pliocene) deposits of the Kashmīr Valley extensive and thick beds of lignite have been discovered by the Mineral Survey Department of Kashmīr. So far, the Nichahom (Handwara) and Shaliganga areas have been mapped and proved, and the estimated quantity available in these areas is 128,000,000 tons, but the presence of lignite in other parts of the valley is also known and a much greater quantity of this fuel is confidently expected. It is not a high class fuel, but it has its other uses for the manufacture of gas, oil and tar, etc. Lignite is also found underlying the Nummulitic limestone of Thakiala, in an outcrop over 18 miles in length. It occurs in lenticular seams, up to 3 feet in thickness, on two horizons, of fair quality, but the high inclination of the seams, and the extreme crushing of the coal, militate against its successful exploitation.

Copper.—Copper-ore, chiefly in the form of the sulphide, chalcopyrite, is common in the schistose beds of the Daling series in Darjeeling district (*supra*, p. 296) and in Sikkim [*Records, Geological Survey of India*, Vol. XLII, 75 (1912)] and in the similar rocks of the Himālayan zone in the Lesser Himālaya of Kumaun.

As a rule the lodes are patchy and irregular and no successful attempt has yet been made to exploit them on a large scale.

Ores of copper have long been known in the Kashmīr State, and old workings are in evidence at Shumahal and Lashtial. The Mineral Survey Department has discovered the presence of copper ore in the copper bed of Gainta and Sukhwal Gali, also in the Rad nāla, Riasi tahsīl, at Kangan, Sindh Valley, Kashmīr, as well as at various places in Kishtwar tahsīl. These deposits have not been examined in any great detail, though some of them have been mapped on a large scale. Not being in the form of regular beds they require careful examination, and it is quite likely that some of them may become useful deposits of copper when properly developed.

Fuller's earth.—Fuller's earth forms a 7-foot bed near Budil, Rajouri tahsīl of Jammu Province, in a slate formation of the older rocks of the area. A large quantity of it is easily available at the surface, but its unfavourable situation, far away from the plains, among the lower hills at the foot of the main Pīr Panjāl ranges, may stand in the way of its being put to any use in the near future.

Gold.—Gold is found in small quantities in the gravels of almost all the chief rivers of the Himālaya [V. Ball: *Manual of the Geology of India*, pt. 3 (1881)] and its recovery provides occupation for the local inhabitants during the winter, when agricultural work is at a standstill.

In the Indus and its tributaries, and in the Sutlej, washing by means of primitive cradles is carried on to a considerable extent, but the results are at present too insignificant to raise this intermittent occupation to the status of a regular industry.

In the Eastern Himālaya, the gravels of the Brahmaputra and neighbouring rivers have long been known to be auriferous [J. M. Maclaren: *Records, Geological Survey of India*, Vol. XXXI, 205 (1904)], but so far no serious attempt has been made to exploit them on modern principles.

In Tibet, the goldfields of Rudok and Thok Jalung have been worked from very early antiquity and Herodotus' reference to the gold-digging ants, with the many ingenious commentaries to which it gave rise, is no doubt familiar to everyone. [For literature on the subject see *Manual of the Geology of India*, pt. 3, Art. *Gold* (1881)]. The output of the Tibetan fields, however, is quite unknown, a circumstance to which the many stories of their fabulous wealth are no doubt to be attributed.

Gold is also found in Afghānistān, but what was formerly the most productive mine in the country, that of Kandahār, has long been closed owing to the miners having lost the vein [C. L. Griesbach: *Memoirs, Geological Survey of India*, Vol. XVIII, pt. 1, 56 (1881)].

Graphite, gypsum, ochres.—Enormous quantities of these minerals occur grouped together along a line of country fifteen miles long, to the north of the Jhelum valley cart-road near Braripura, in the Uri tahsīl of Kashmīr.

The ochres, especially those of Rata Sar, are fairly rich in colouring matter, and need but little preparation to make good oil paints. About 160,000 tons are known at the surface in this locality; they are also known at Jhuggi and Nur Khwah in Uri tahsīl.

The graphite of the above locality is of the amorphous variety; it is distributed through a 400-foot thickness of phyllites and contains only 25 to 30 per cent carbon.

In addition to the above, flake graphite is also found in the Kashmīr State in the neighbourhood of the sapphire mines, Padar, Kishtwar. It is distributed as flakes in a number of bands varying in thickness from 6 feet to as much as 30 to 40 feet, and having a great extension along the strike. The quantity available of both varieties is certainly very great.

Gypsum.—The gypsum is a pure alabaster-like product of the alteration of a pyritiferous limestone. Hundreds of millions of tons, forming mountain sides, lie exposed for easy quarrying.

Gypsum also occurs in thick beds, as the product of the alteration of limestone, in lower Spiti, at a short distance above the junction of the Spiti and Sutlej rivers. Although the quantity available is very large and the quality high, the locality is too far from markets and too inaccessible to offer any prospects of remunerative exploitation of the deposits [H. H. Hayden: *Memoirs, Geological Survey of India*, Vol. XXXVI, pt. 1, 101 (1904)].

Iron.—Iron-ore is known to occur in some quantity in the lower hills in Kumaun [T. H. Hughes: *Records, Geological Survey of India*, Vol. VII, 15 (1874)], where numerous attempts have been made to establish a smelting industry on a commercial basis. All attempts failed however, presumably owing to the cost of transport of ore and fuel and there does not seem to be much prospect of a successful revival of the industry.

As in most other parts of India, iron was once worked at several places in Jammu and Kashmīr; the excellent suspension bridge at Ramban over the Chenāb River was built of iron smelted from the ores of Chakar, Matah or Salal in Riasi tahsīl of Jammu Province (where innumerable pits are still noticeable honeycombing the country), during the rule of late Mahārāja Ranbīr Singh. These deposits have not yet received the serious attention of the Mineral Survey of Kashmīr, but a 15-foot thick bed of pure hæmatite has been located by the Mineral Survey at Khandli in Rajouri, forming lenticular masses of sometimes great extension in the Nummulitic series, whose continuation towards the north-west has also been proved. This ore contains 60 per cent of iron.

Lead, silver.—The galena deposits of Buniar in Uri tahsīl, Kashmīr, have been explored at various times in a desultory way and without much success. Recent work there by the Mineral Survey of Kashmīr has indicated the probability that these galena veins form the north-western continuation of the Ramsu and Khaleni occurrences recently discovered, along the line of strike of the containing rocks. The galena from these localities has been found to contain 0·1 per cent silver. Old workings of galena are also known in Nigote sub-division of Riasi tahsīl, and much ore is alleged to have been won from them in the past.

Recent work by the Mineral Survey has shown the occurrence of galena at various other places in the Great Limestone formation of Riasi tahsīl, along the line of strike of the Nigote deposit.

During his survey of Chitrāl, Mr. G. H. Tipper found numerous occurrences of galena, zinc-blende, copper and iron pyrites, tetrahedrite and jamesonite in the quartzitic portions of the Sarikol shales, and galena associated with azurite, occurs at Chapari.

Manganese.—Manganese ore has been located recently at a place 1 mile west of Lidrer nala, Padar, Kishtwar, where it is found impregnating a quartz vein 200 feet long and 4 feet thick. No analysis has so far been made.

Marble and serpentine.—Marble of fair quality is known in several places in Kashmīr. A layer of it, white to grey in colour, near Braripura, is available for

ornamental building purposes in very large quantities. Other excellent marbles and serpentines are found distributed in the higher hilly areas. These, except the translucent apple-green serpentine ("Zehr Mohura", the poison detector) from Shigar, are too far away from civilisation to be of economic value. The "Zehr Mohura" is carved into small cups and other articles and has a pleasing appearance.

Mercury.—Cinnabar has been detected in concentrates from auriferous sands from the Chitrāl river [*Records, Geological Survey of India,* Vol. LIV, 26 (1922)].

Nickel.—Ores of nickel have recently been discovered at Ramsu, Buniar and Khaleni, and also in the neighbourhood of the Sapphire Mines, Padar, and in the copper-bearing horizon of Riasi tahsīl, all in Kashmīr. The surface samples in certain cases gave a good percentage of nickel (in one case 1·68 per cent), but no opportunity has been found so far to examine these occurrences in any great detail.

Petroleum.—The development of the Khaur Oilfield near Rāwalpindi by the Attock Oil Company, and the recent discovery of a bituminous horizon with thin veins of asphalt at various places in the Jammu Province of Kashmīr, hold out hopes that liquid fuel in the form of petroleum, may be hidden in one or more suitable geological structures, such as the Nar-Budhan dome and the Ramnagar "terrace" already discovered. Others may be brought to light by future survey work in rocks of the same age and composition as those existing at Khaur. But this is a matter about which there can be no certainty until deep drilling is undertaken.

Crude oil and many other useful by-products can also be obtained from lignite by its distillation, as the following yield per ton of Kashmīr lignite shows :—

Liquor	55·83 gallons.
Sulphate of ammonia	10·85 lbs.
Oil	5·43 gallons.
Spirit from gas scrubber	1·00 gallons.
Gas	(about) 4,250 c. ft.

Talc (steatite).—A pure, compact, translucent talc of the palest shade of yellowish green occurs in the Great Limestone at several places in the Riasi tahsīl of Jammu Province in Kashmīr. Others of a slate-grey colour are also found. The several exposures have been surveyed, and thick veins located and mapped, but their underground continuation cannot be determined without development work. There is enough visible for anyone interested in the trade to start work upon.

Zinc.—Zinc blende occurs in the Great Limestone near Darabi, Riasi tahsīl, Kashmīr, forming veins and lenticles in it. The ore lenticles vary in dimensions from a few cubic feet to as much as 576 cubic feet, and the veins vary in length from a few inches to as much as 150 feet and in width from a few inches to 10 feet. A specimen of pure ore gave on analysis 67·52 per cent zinc. Cadmium to the extent of 0·174 per cent has also been reported to be present in it. Zinc-bearing calcite veins also occur at various other places in the Great Limestone on the line of strike of the Darabi occurrence. On account of its lenticular nature only actual mining can prove the depth of the ore. A few thousand tons could be collected from the surface.

LIST OF PAPERS ON THE ECONOMIC GEOLOGY OF KASHMIR.

MOSTLY BY

C. S. MIDDLEMISS.

(1) Note on the Aquamarine mines of Daso on the Braldu R., Shigar Valley, Baltistān. (Published in *Records, Geological Survey of India,* Vol. XLIX, pt. 3, 1918, with plates 6 to 10.)

(2) Possible occurrence of Petroleum in Jammu Province: Preliminary note on the Nar-Budhan dome of Kotli tahsīl in the Punch Valley. (Published in *Records, Geological Survey of India,* Vol. XLIX, pt. 4, 1919, with plates 13 to 16.)

(3) Lignitic Coalfields in the Karewa formation of the Kashmīr Valley. (Published in *Records, Geological Survey of India,* Vol. LV, pt. 3, 1923, with plates 28 to 30.)

(4) Abrasives: Note on the polishing material of Risin Spur, Khunamuh, near Srīnagar. (Printed by order of the Kashmīr Government, with plates 1 and 2.)

(5) The Graphite deposits of Braripura, Uri tahsīl, Kashmīr. (Printed by order of the Kashmīr Government, with plates 1 to 5.)

(6) Ochre deposits of Nur Khwah, Rata Sar and Jhuggi in the Jhelum Valley, Uri tahsīl, Kashmīr. (Printed by order of the Kashmīr Government, with plates 1 to 6.)

(7) The Gypsum deposits of the Lachhipura, Bagna, Islāmābād, Limbar and Katha nalas, Uri tahsīl, Kashmīr. (Printed by order of the Kashmīr Government.)

(8) Bauxite deposits of Jammu Province. (Printed by order of the Kashmīr Government, with plates 1 to 17.)

(9) A Resurvey of Jammu Coalfields: The Kalakot, Metka and Mahogala fields, with notes on the Chakar, Chinkah and newly discovered Dhansal-Sawalkot fields. (Printed by order of the Kashmīr Government, with plates 1 to 25.)

(10) Ore deposits of Lead, Copper, Zinc, Iron and other metals in Jammu and Kashmīr State. (Published by order of the Kashmīr Government, with plates 1 to 16.)

(11) Non-Metallic Minerals of Jammu and Kashmīr. (Printed by order of the Kashmīr Government, with plates 1 to 7.)

(12) Precious and semi-precious gemstones of Jammu and Kashmīr. (Published by order of the Kashmīr Government, with plates 1 to 7.)

INDEX

to the most important

Personal and Geographical names of Parts I, II, III & IV.

The values of latitude and longitude given in this index to the more important geographical names occurring in Parts I, II, III and IV, are intended only as rough aids to the localisation of places on maps: as many of these values have been derived from small scale maps, the index should not be utilized in scientific discussions or controversies. In certain cases, more specially in those of Tibetan lakes and of passes and glaciers, the values of latitude and longitude rest on doubtful evidence and have been entered only to enable future explorers to correct our figures. In cases when two or more peaks bear the same name, mean values of latitude and longitude have been given in this index.

* The picture of Bandarpūnch will be found facing p. 6 of Part I.

* The picture of Nanga Parbat peak will be found facing p. 6 of Part I.
† The picture of Nojli Tower will be found facing p. 53 of Part I.

INDEX OF SUBJECTS.

Q 2

MGIPC—M—III-5-12—3-2-34—1,000.

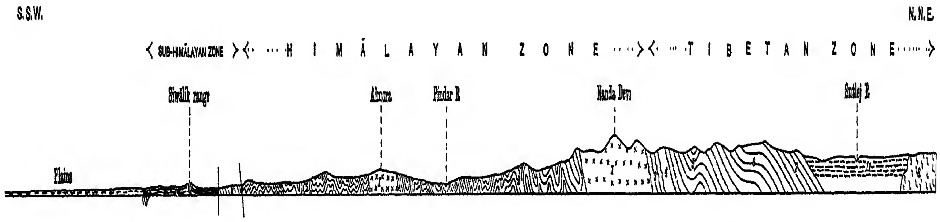
DIAGRAMMATIC

SECTIONS ACROSS THE HIMĀLAYA

PLATE XXXVIII

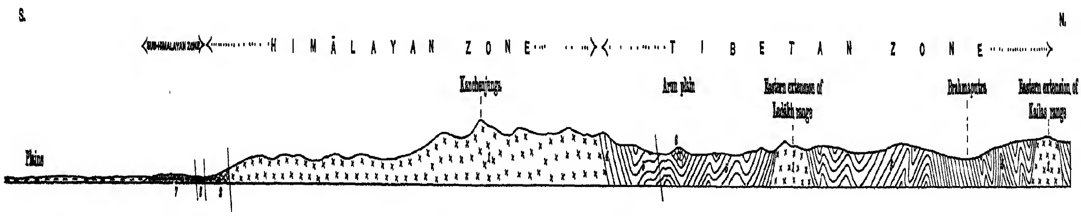
1 Granite 2 Purana group 3 Haimanta system 4 Muth, Kanawar and Kuling systems 5 Lilang system 6 Indus valley Tertiaries 7 Sirmūr series 8 Lower Siwālik 9 Upper Siwālik

FIG. 1. THROUGH SPITI TO THE INDUS.



1 Granite 2 Purana group 3 Vaikrita system 4 Haimanta system 5 Muth and Kuling systems 6 Lilang system 7 Cretaceous and Eocene 8 Ngari Khorsum volcanics 9 Lower Siwālik 10 Upper Siwālik 11 Pleistocene of Ngari Khorsum

FIG. 2. THROUGH NANDA DEVI TO THE SUTLEJ.



1 Granite and Crystalline rocks 2 Daling series 3 Gondwanas 4 ? Trias 5 Jurassic 6 Kampa system (Cretaceous and Eocene) 7 Siwālik series

FIG. 3. THROUGH KANCHENJUNGA TO THE BRAHMAPUTRA.

Horizontal and Vertical Scales 1 Inch = 16 Miles.

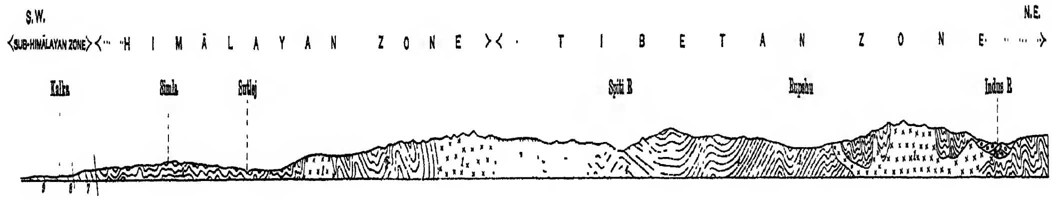
REG.No.93M.D.1932.

HELIOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, DEHRA DUN.

DIAGRAMMATIC

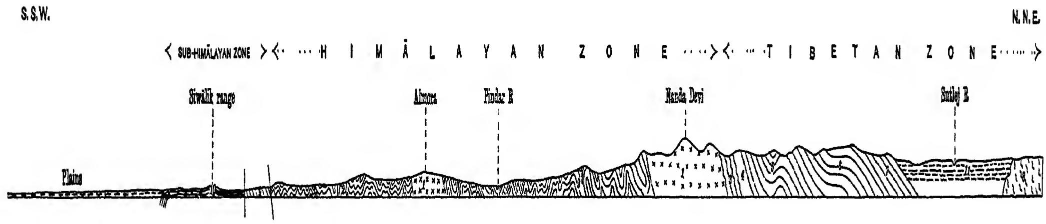
SECTIONS ACROSS THE HIMĀLAYA

PLATE XXXVIII



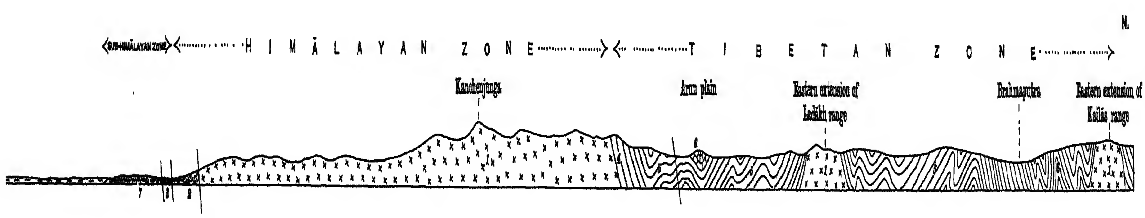
1 Granite 2 Purana group 3 Haimanta system 4 Muth, Kanawar and Kuling systems 5 Lilang system 6 Indus valley Tertiaries 7 Sirmūr series 8 Lower Siwālik 9 Upper Siwālik

FIG. 1. THROUGH SPITI TO THE INDUS.



1 Granite 2 Purana group 3 Vaikrita system 4 Haimanta system 5 Muth and Kuling systems 6 Lilang system 7 Cretaceous and Eocene 8 Ngari Khorsum volcanics 9 Lower Siwālik 10 Upper Siwālik 11 Pleistocene of Ngari Khorsum

FIG. 2. THROUGH NANDA DEVI TO THE SUTLEJ.



1 Granite and Crystalline rocks 2 Daling series 3 Gondwanas 4 ? Trias 5 Jurassic 6 Kampa system (Cretaceous and Eocene) 7 Siwālik series

FIG. 3. THROUGH KANCHENJUNGA TO THE BRAHMAPUTRA.

Horizontal and Vertical Scales 1 Inch = 16 Miles.

HELIOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, DEHRA DUN.

FOLDING IN THE SUB-HIMĀLAYAN ZONE

PLATE XXXIX

Fig. 1. Simple folding.

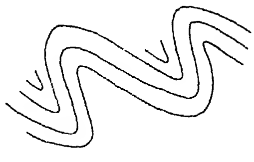


Fig. 2. Reversed folding.

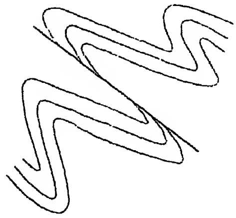


Fig. 3. Overthrust.

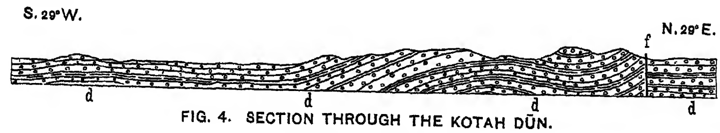


FIG. 4. SECTION THROUGH THE KOTAH DŪN.

Scale 1 Inch=1½ Miles.

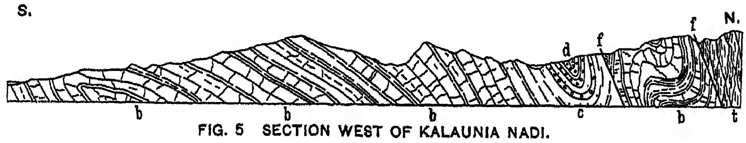


FIG. 5 SECTION WEST OF KALAUNIA NADI.

Scale 1 Inch=1½ Miles.

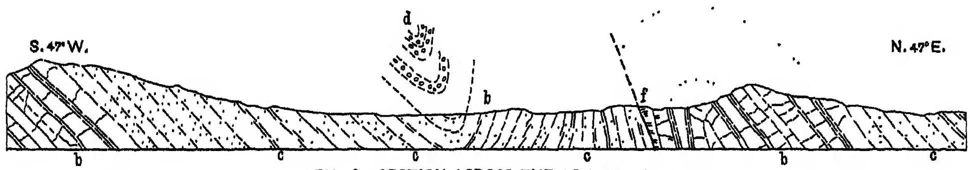


FIG. 6. SECTION ACROSS THE SONA NADI.

Scale 1 Inch=1 Mile.

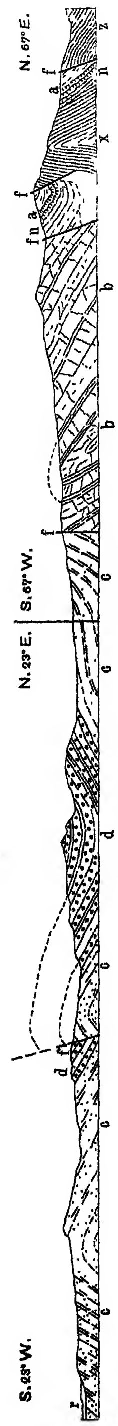


FIG. 7. SECTION EAST OF THE GANGES.

Scale 1 Inch=1½ Miles.

FIGS. 4 to 7. SECTIONS THROUGH THE SUB-HIMĀLAYA OF GARHWĀL AND KUMAUN.

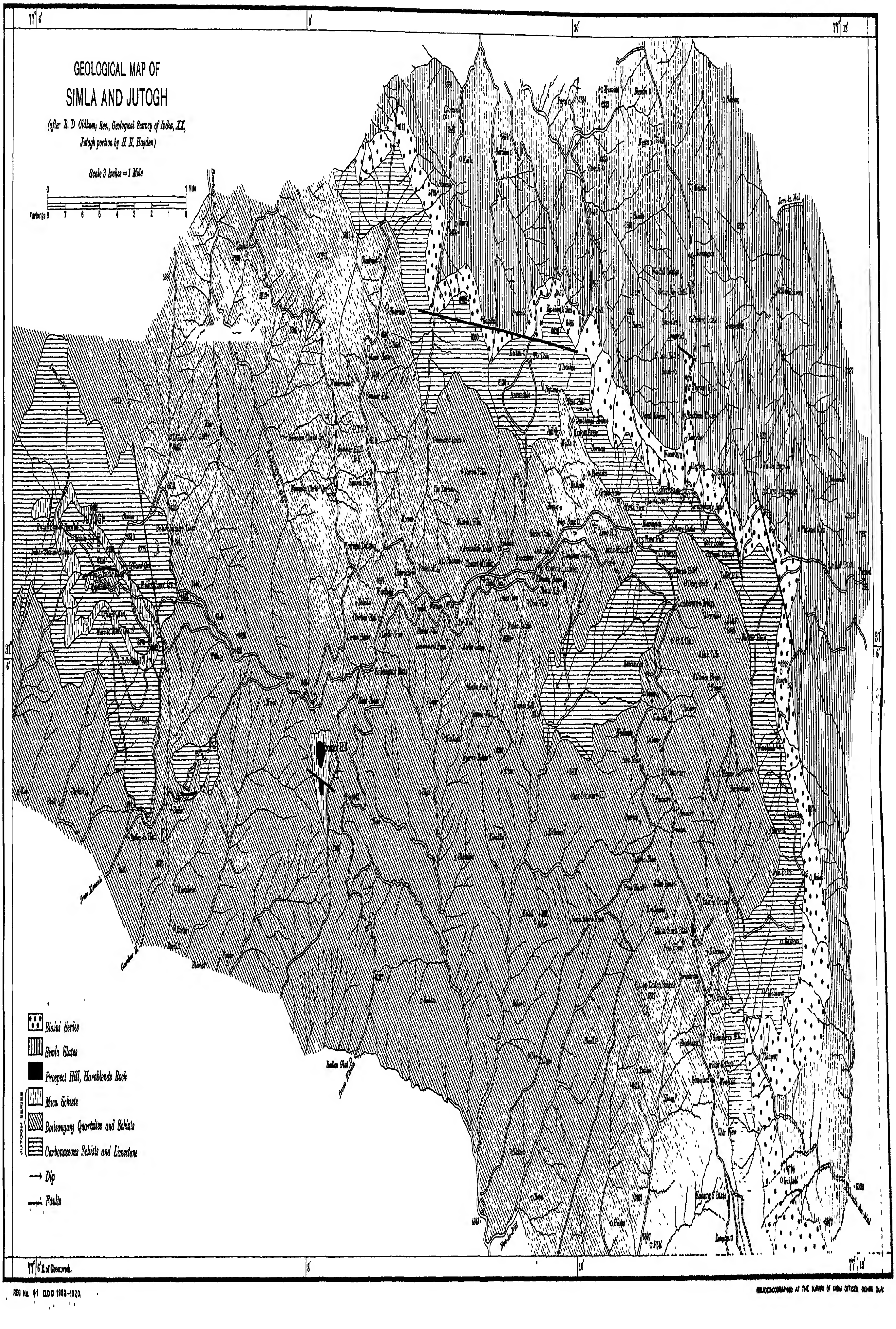
(*after C. S. Middlemiss. Mem., Geological Survey of India, XXIV, Pt. 2.*)

r = Recent.
d = U. Siwālik Conglomerate.
c = M. Siwālik sand rock.
b = L. Siwālik (Nāhan) sandstone.
a = Nummulitic.

n = Tal series.
t = Trap.
x = Purple slate.
z = Crystalline schist.
f = Faults.

HELIOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, DEHRA DUN.

PLATE XL



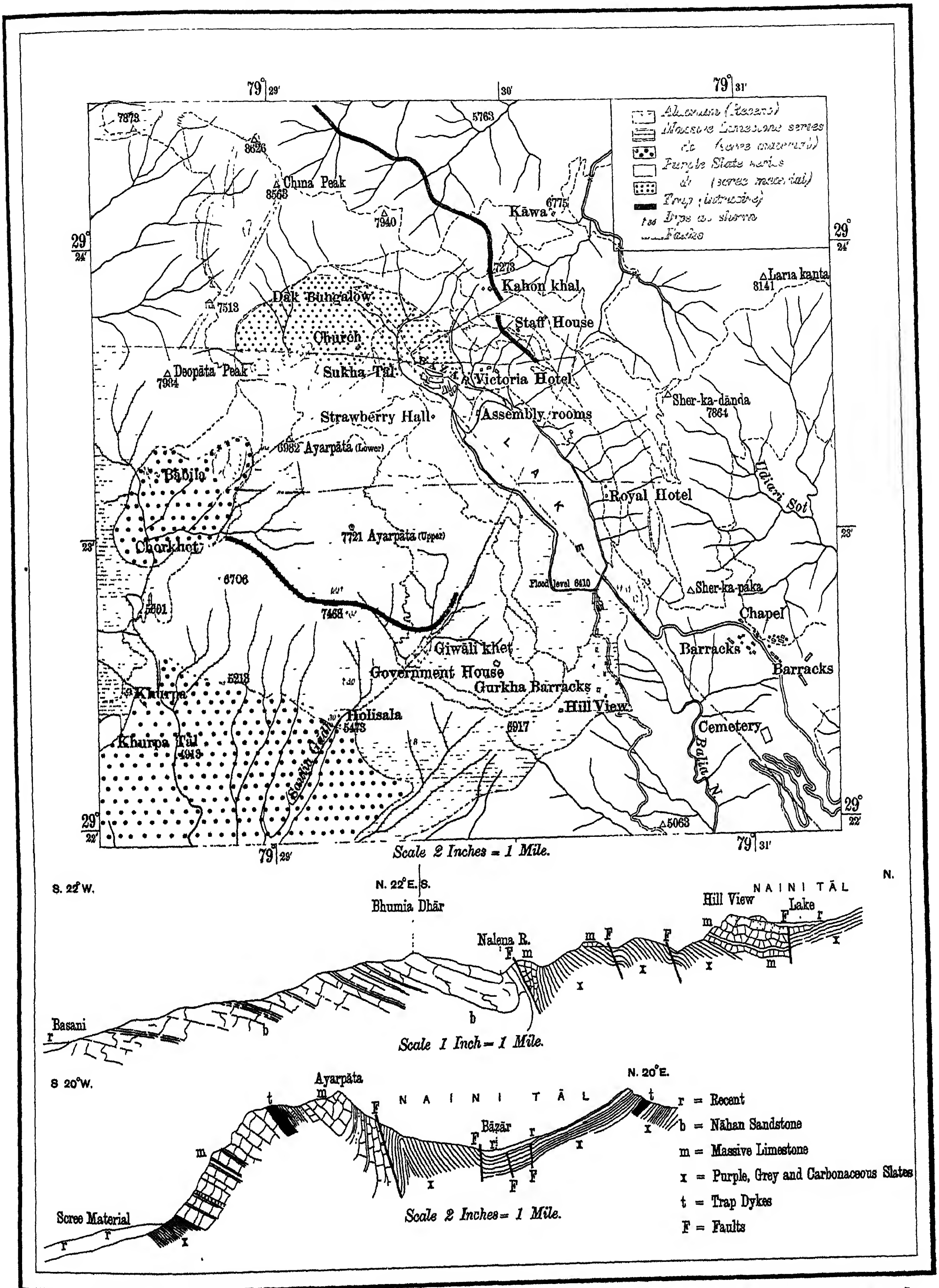
PHOTOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, DEHRA DUN

GEOLOGICAL MAP AND SECTIONS OF

NAINI TĀL

(after C. S. Middlemiss: Rec., Geological Survey of India XXIII)

PLATE XLI



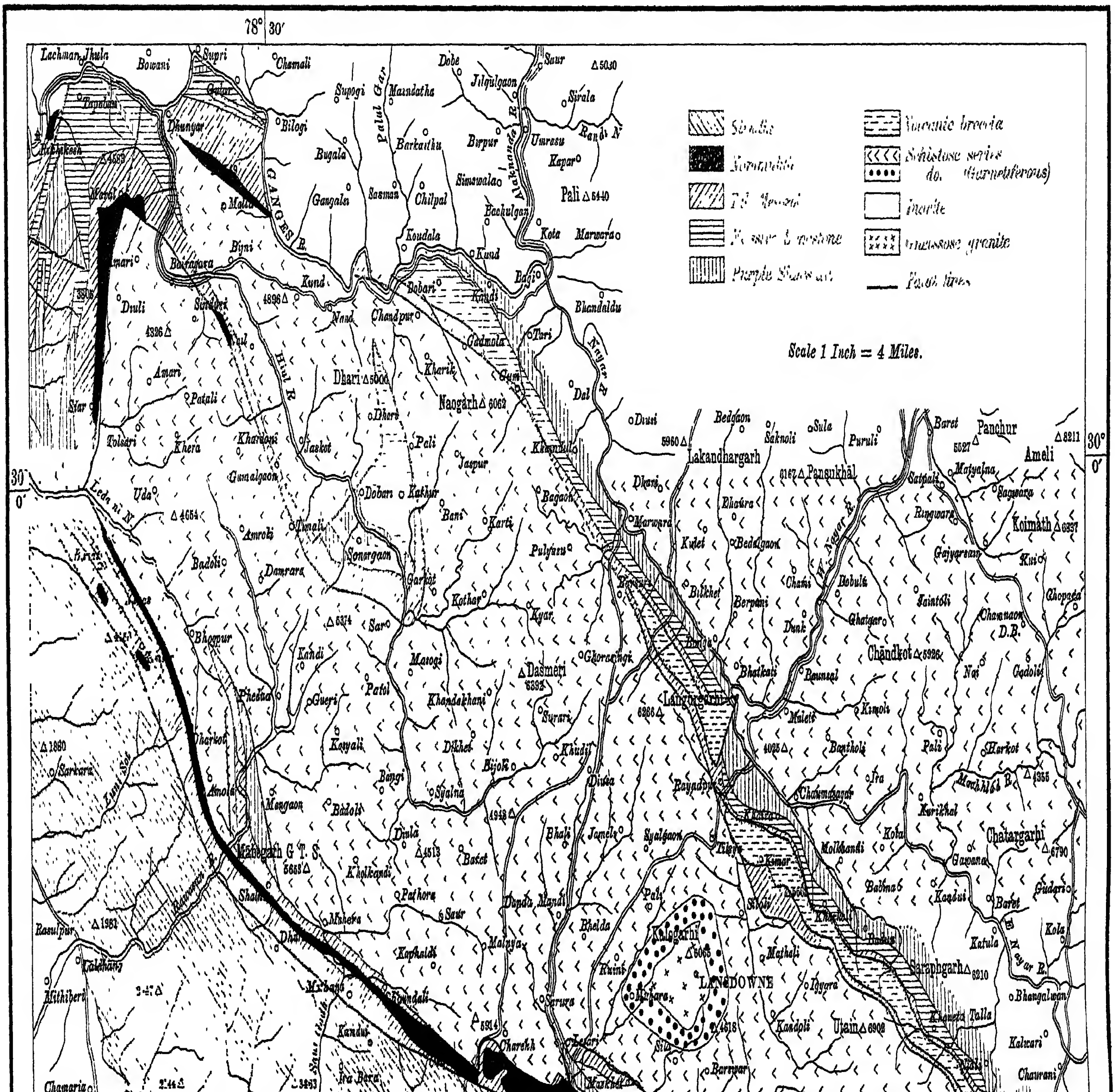
REG.No 6 D.O.D 1932.

HELIOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, DEHRA DŪN.

TĀL SERIES
IN WESTERN GARHWĀL

(after C. S. Middlemiss: Rec., Geological Survey of India, XX)

PLATE XLII



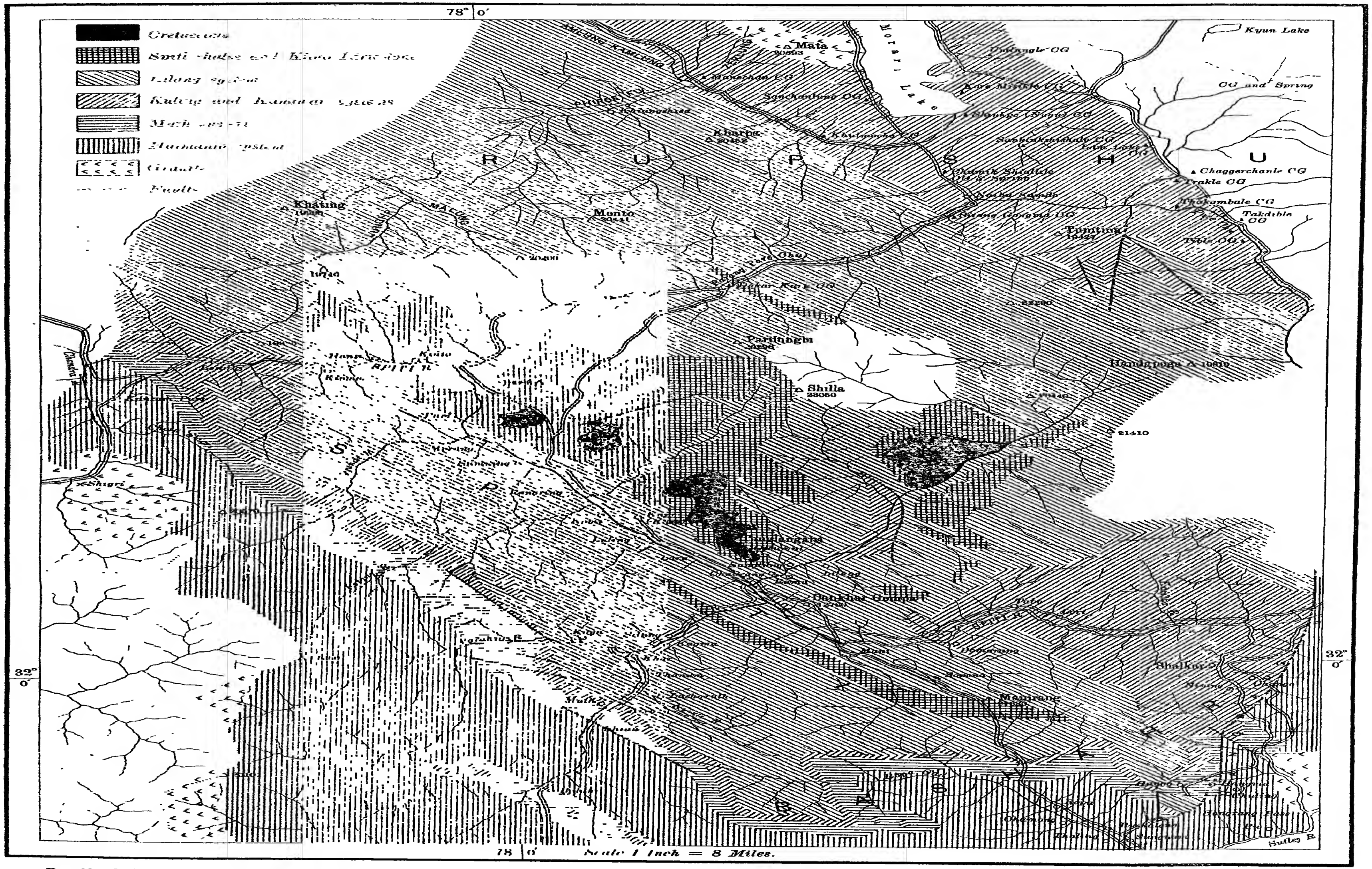
Heliozincographed at the Survey of India Offices, Dehra Dun.

REG. No. 7 D.D.O.1932

GEOLOGICAL MAP OF SPITI AND RUPSHU

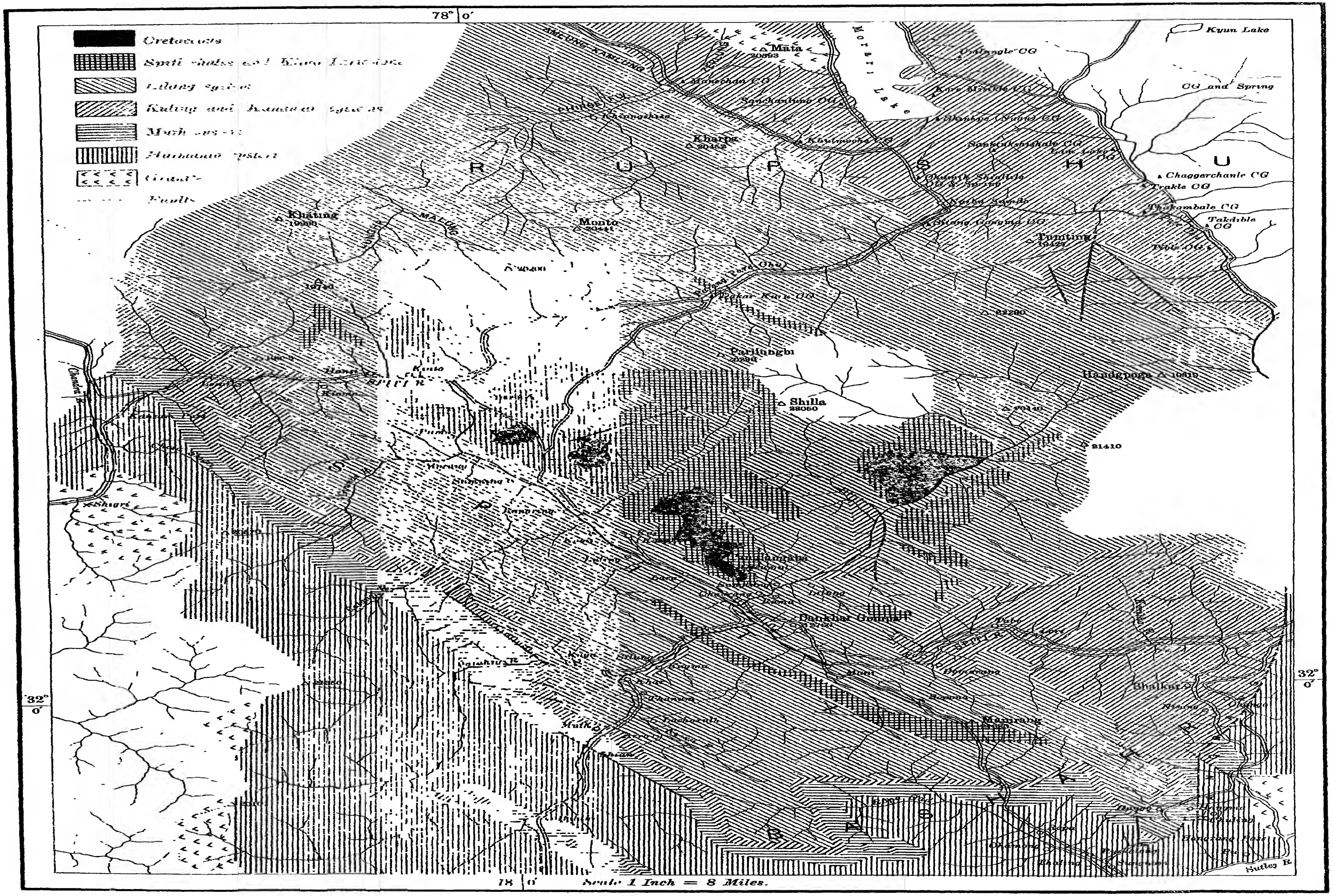
(after H. H Hayden and A von. Krafft: Mem., Geological Survey of India, XXXVI, pt 1)

PLATE XLIII



Reg. No 8 D D D   1932.

HELIOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, DEHRA DUN

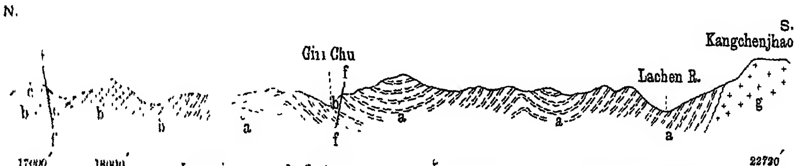


Reg. No 8 D.D.D 1932.

HELIOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES, DEHRA DUN

SECTIONS ACROSS THE TIBETAN ZONE IN SPITI, TIBET AND KUMAUN

PLATE XLIV



a. Jurassic. b. Cretaceous. c. Tertiary g. Gneiss and Granite.

FIG. 1. SECTION FROM KANGCHENJHAO TO KAMPA RIDGE, TIBET.

(after H. H. Hayden, Mem., Geological Survey of India, XXXVI, pt. 2)

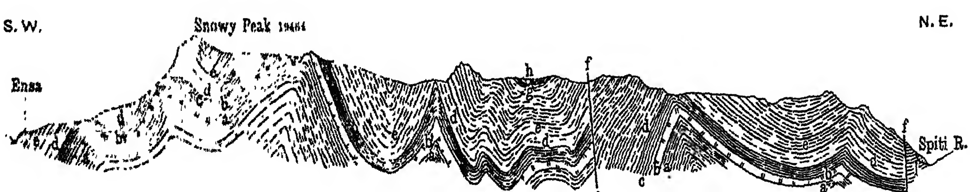
Scale 1 Inch = 4 Miles.

2. Haimanta system
3. Muth system
4. Productus shales.
5. Lilang system.

FIG. 2. SECTION BETWEEN THE EAST SLOPE OF THE BAMBADHURA AND THE DHAULI GANGA, KUMAUN

(after C. L. Griesbach, Mem., Geological Survey of India, XXIII)

Scale 1 Inch = 2 Miles.



a. Juvavites beds.
b. Coral limestone.
c. Monotis shales.
d. Quartzite series.

f. Faults

e. Megalodon (Para) limestone
g. Jurassic (Taglıng) limestone
h. Spiti shales.
l. Daonella shales.

FIG. 3. SECTION FROM SPITI RIVER, ABOVE MANI, TO ENSA.

(after H. H. Hayden, Mem., Geological Survey of India, XXXVI, pt. 1.)

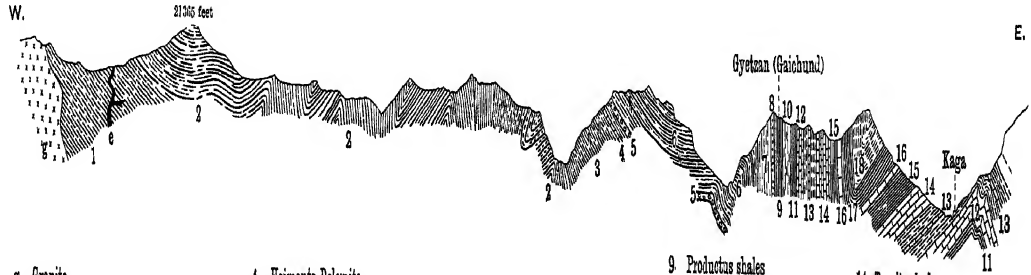
Scale 1 Inch = 2 Miles.

REG No 12 D D D 1932

Helıozıncographed at the Survey of India Offices, Dehra Dun.

SECTIONS ACROSS THE TIBETAN ZONE IN SPITI, KUMAUN AND HAZĀRA

PLATE XLV

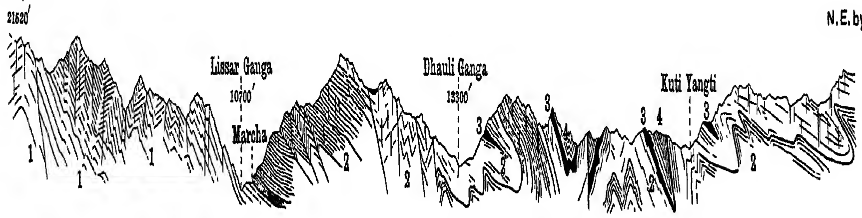


g. Granite
e. Epidiorite
1. Haimanta slates and quartzites, altered by contact with igneous rocks
2. Haimanta slates
3. Haimanta trilobite beds
4. Haimanta Dolomite
5. Muth Conglomerate
6. Red (lower silurian) quartzite
7. Muth limestone
8. Muth quartzite
9. Productus shales
10. Otoceras zone to muschelkalk
11. Daonella shales
12. Daonella limestone
13. Grey shales
14. Tropites beds
15. Juvavites beds
16. Coral limestone
17. Monotis shales
18. Quartzite series

FIG. 1.—SECTION ALONG THE PARAHIO RIVER, SPITI.

(after H. H. Hayden: Mem., Geological Survey of India, XXXVI, pt. 1)

Scale 1 Inch = 2 Miles.

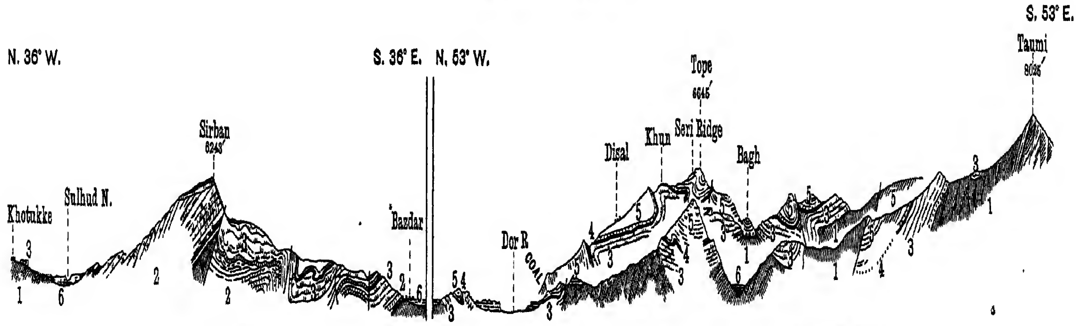


1. Haimanta system
2. Muth system
3. Productus shales
4. Lilang system

FIG. 2.—SECTION BETWEEN THE NAULPHU NIPCHUNG HEIGHTS AND THE RANGE WHICH DIVIDES THE KUTI YANGTI FROM HUNDES, SOUTH OF THE MANKSHANG.

(after C. L. Griesbach: Mem., Geological Survey of India, XXIII)

Scale 1 Inch = 3 Miles.



1. Slate series
2. Infra Trias
3. Trias
4. Jura-Cretaceous
5. Tertiary
6. River Gravels

FIG. 3.—SECTION IN HAZĀRA FROM SIRBAN TO TAUMI.

(after C. S. Middlemiss: Mem., Geological Survey of India, XXVI)

Scale 1 Inch = 1 Mile.

REG No. 13. D D.D. 1932

Heliozincographed at the Survey of India Offices, Dehra Dun.

GEOLOGICAL MAP AND SECTIONS OF MALLA JOHĀR

(after A. von. Krafft· Mem, Geological Survey of India, XXXII, pt 3)

PLATE XLVI

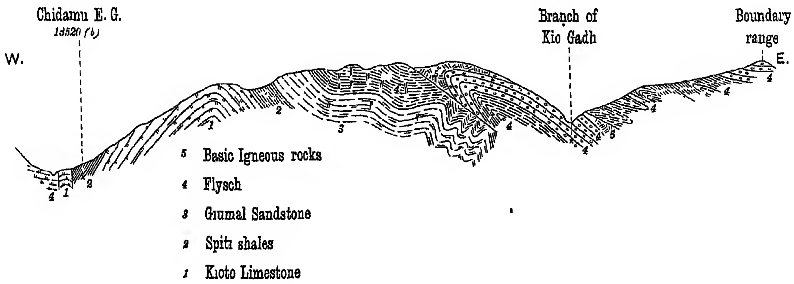
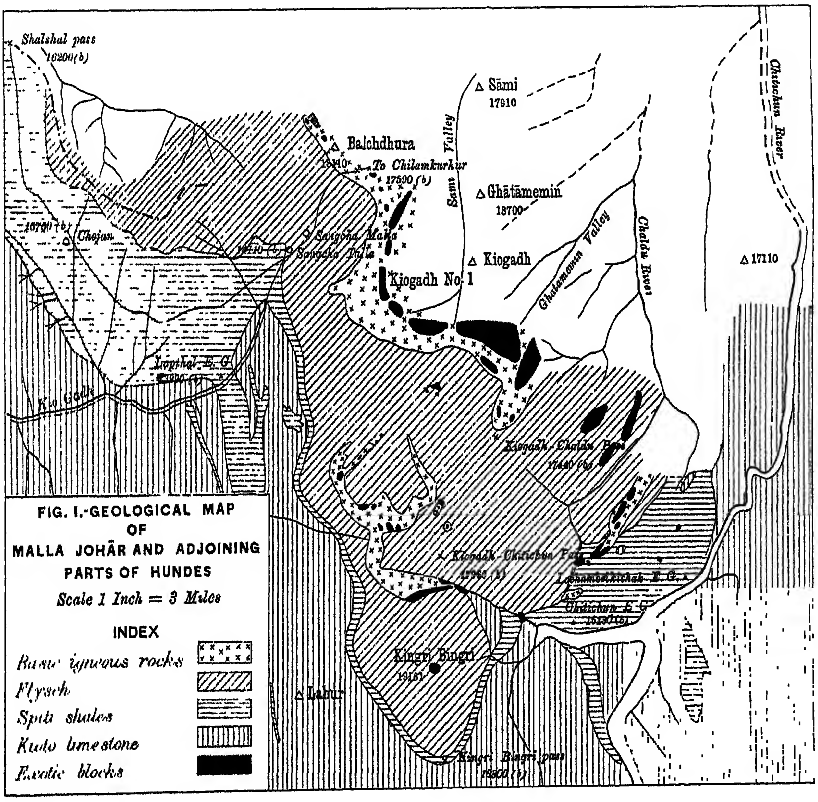


FIG. 2. SECTION THROUGH COUNTRY S OF THE KIO GADH.



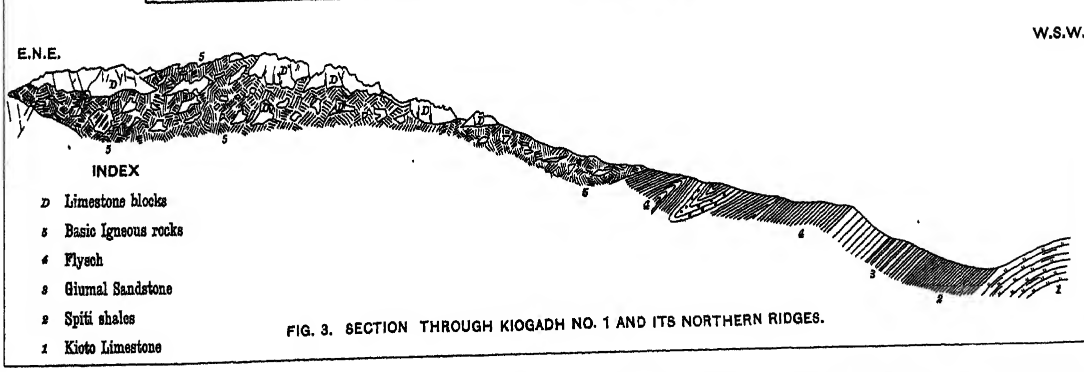
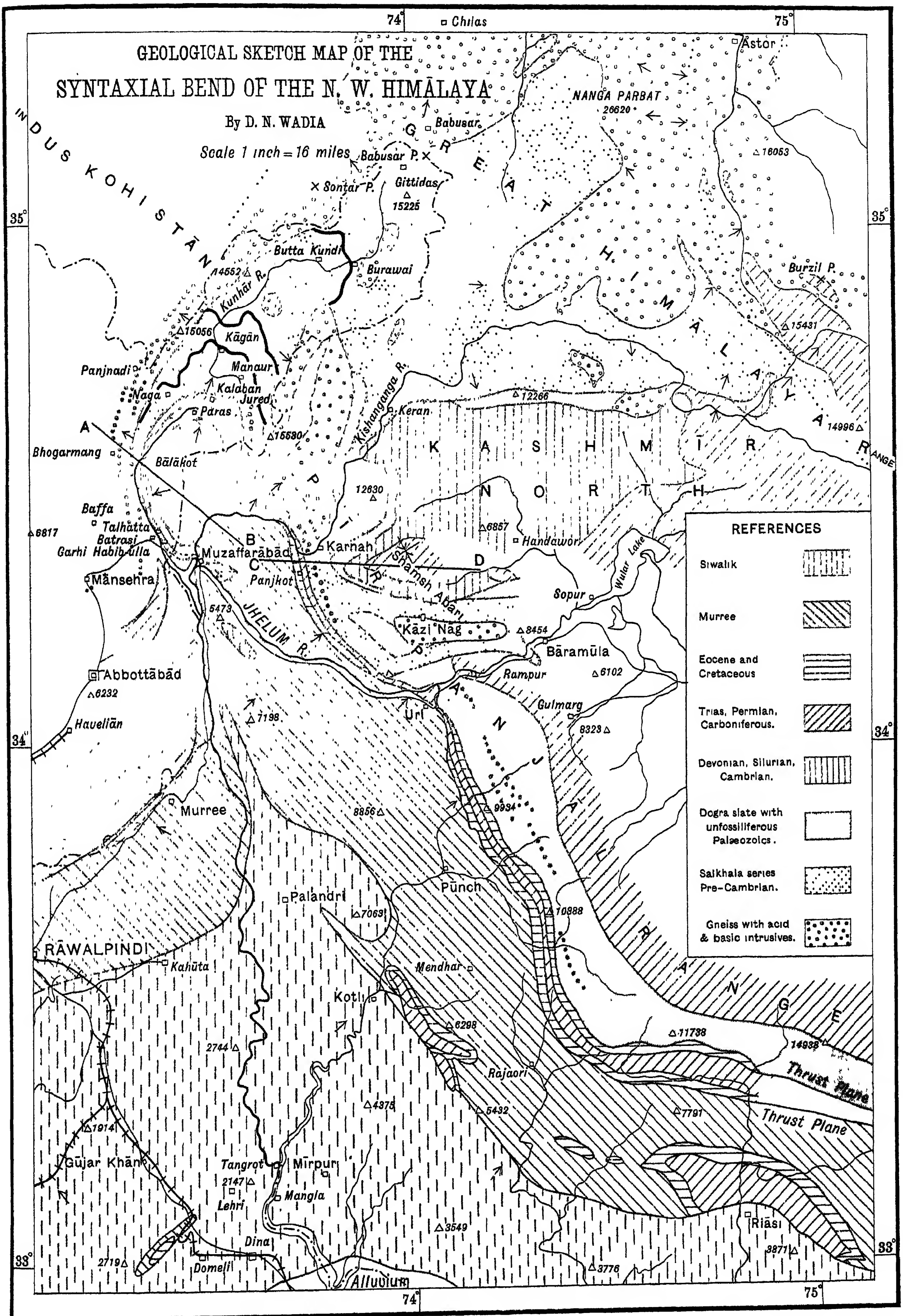


FIG. 3. SECTION THROUGH KIOGADH NO. 1 AND ITS NORTHERN RIDGES.

Heliozincographed at the Survey of India Offices, Dehra Dūn.
REG. No 14 D.D.D 1932



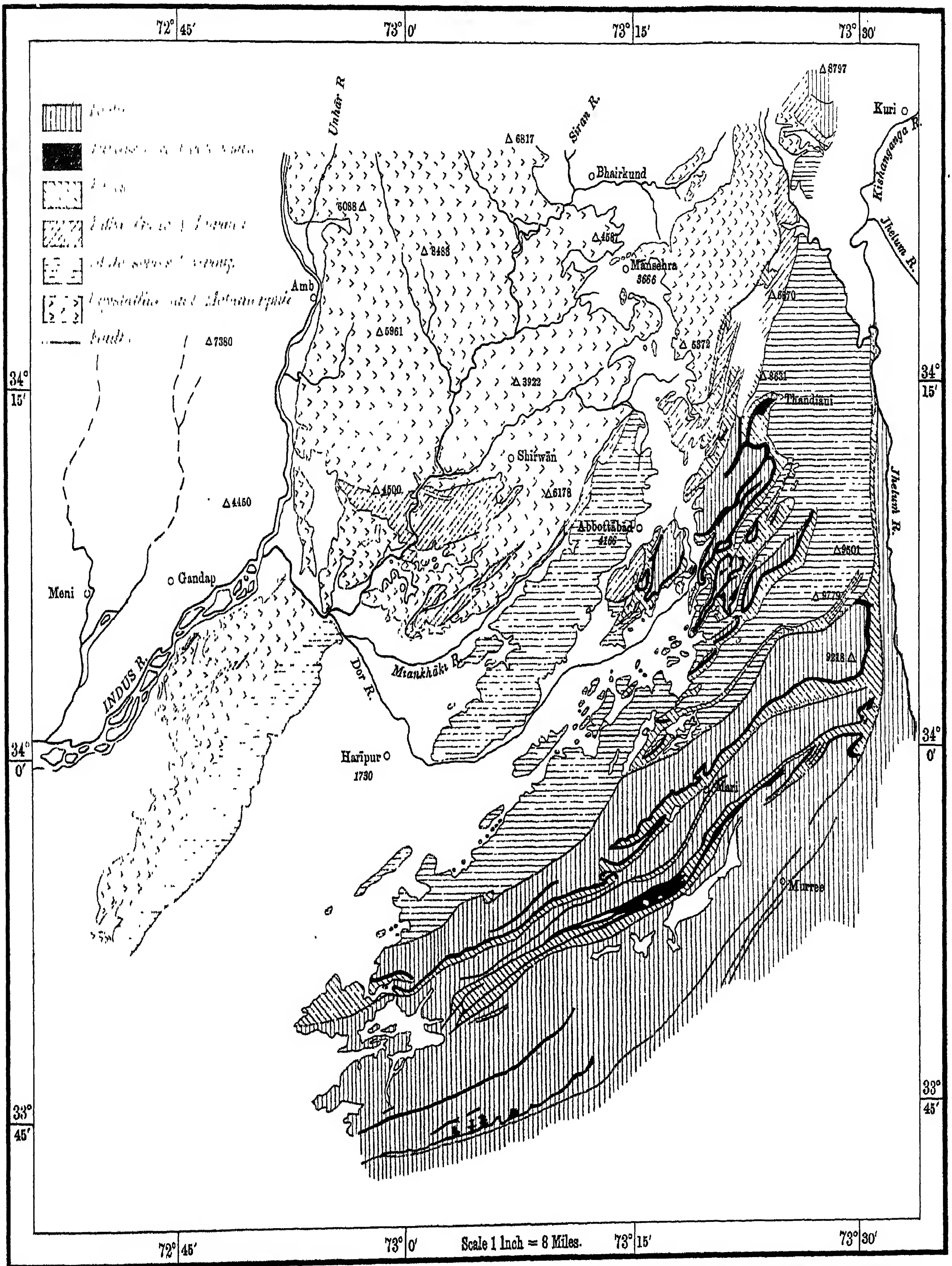
Reg No 18 D.D.D. 32

Helio S.I O.Dehra Dūn

GEOLOGICAL MAP OF HAZĀRA

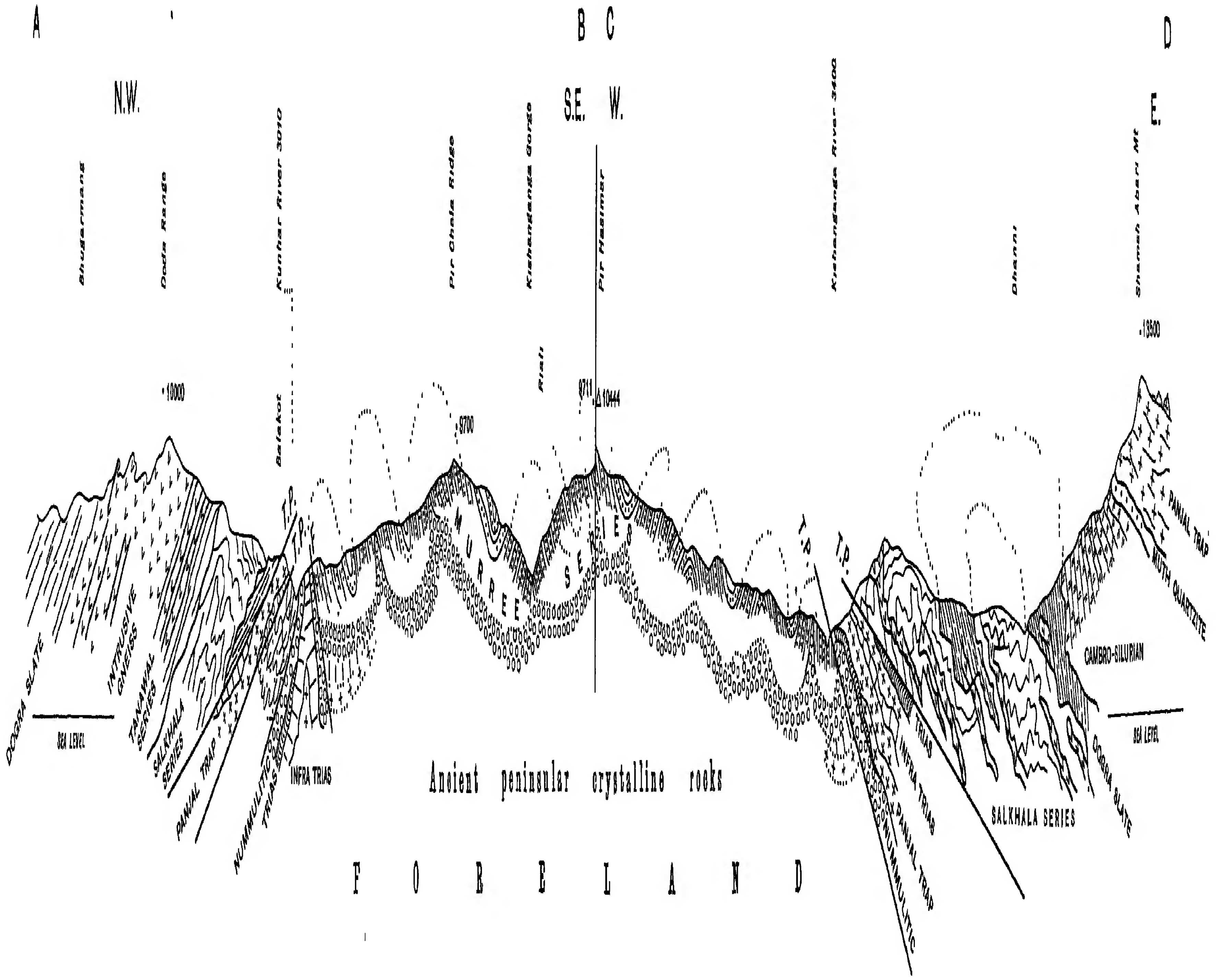
(after C. S. Middlemiss: Mem., Geological Survey of India, XXVI).

PLATE XLIX



REG. No. 15. D.D.D 1932

Heliozincographed at the Survey of India Offices, Dehra Dun



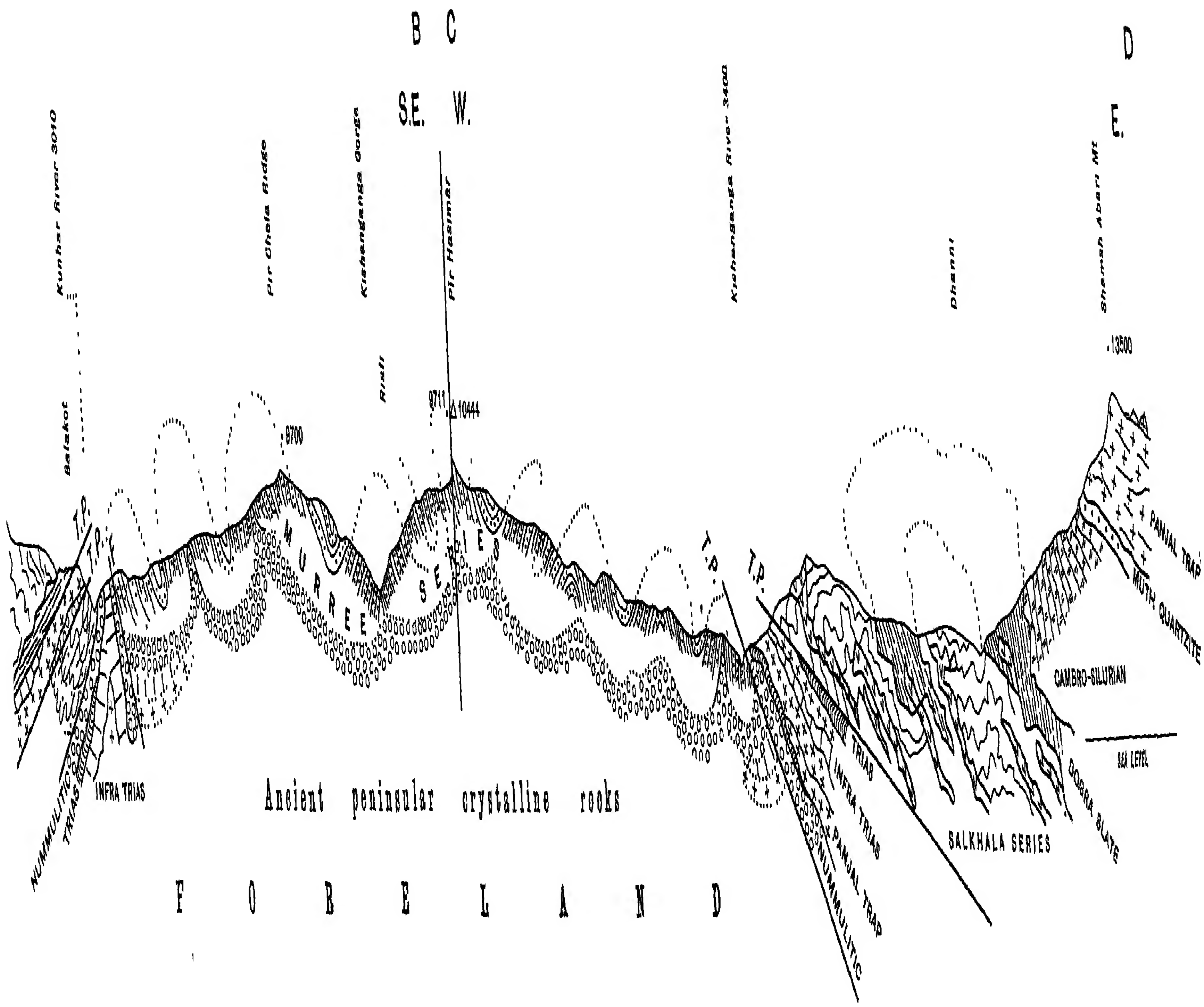
REG. No 9 D, D D 1932

SECTION ACROSS THE SYNTAXIAL BEND OF THE N.W. HIMĀLAYA. (FROM EAST HAZĀRA TO WEST KASHMĪR)

ALONG THE LINE A B-C D

Scale 1 inch = 2 miles horizontal & vertical.

Heliozincographed at the Survey of India Offices, Dehra Dun.



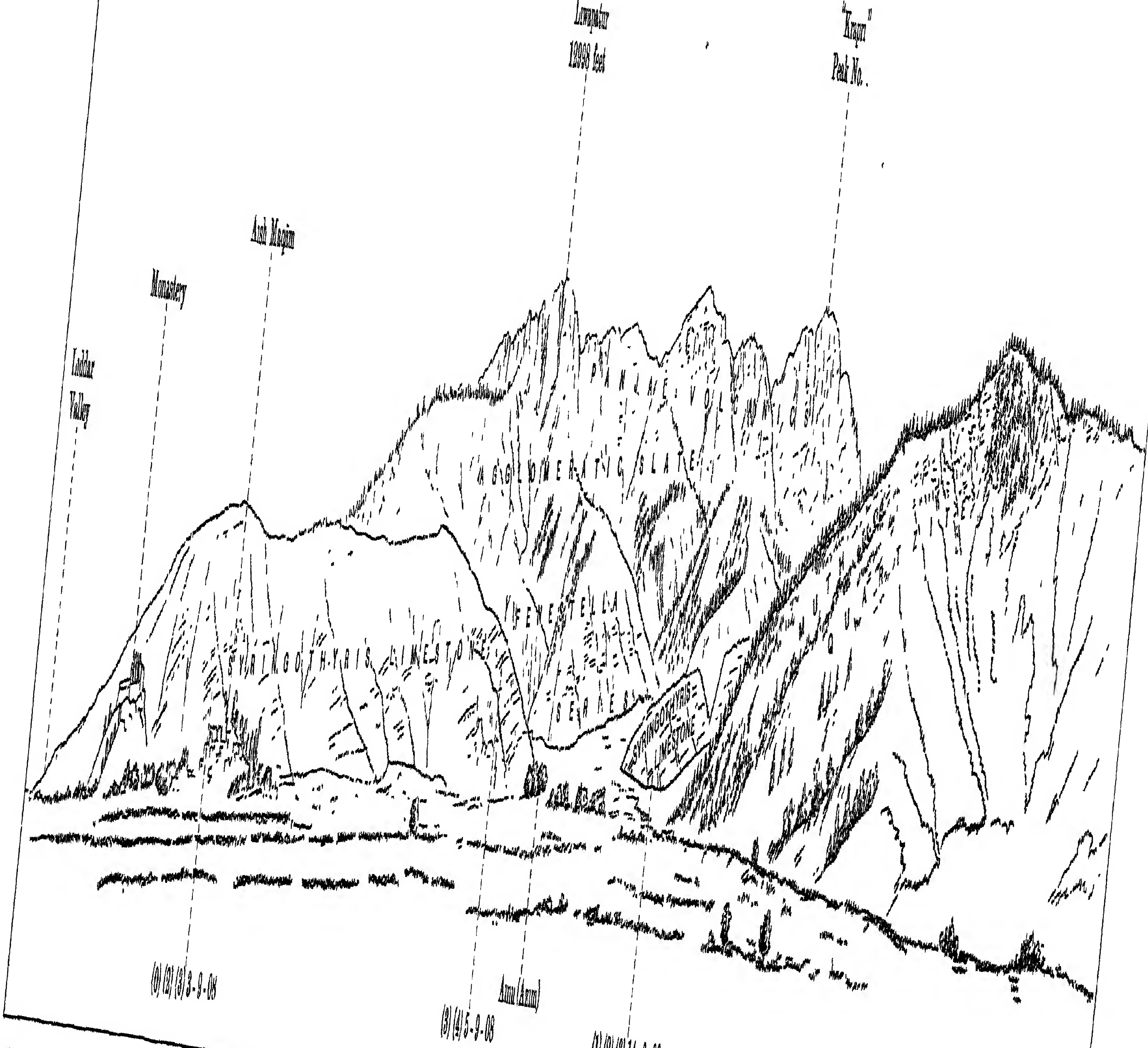
SECTION ACROSS THE SYNTAXIAL BEND OF THE N.W. HIMĀLAYA. (FROM EAST HAZĀRA TO WEST KASHMĪR)

ALONG THE LINE A B-C D

Scale 1 inch = 2 miles horizontal & vertical.

Heliozincographed at the Survey of India Offices, Dehra Dun.

PLATE LII (Fig. 2)



From camera lucida sketch by C. S. Middlemiss. Reg No 20 D D D 1932

VIEW N. E. FROM NEAR AISH MAQĀM, KASHMĪR

Helio 610 Dehra Dūn